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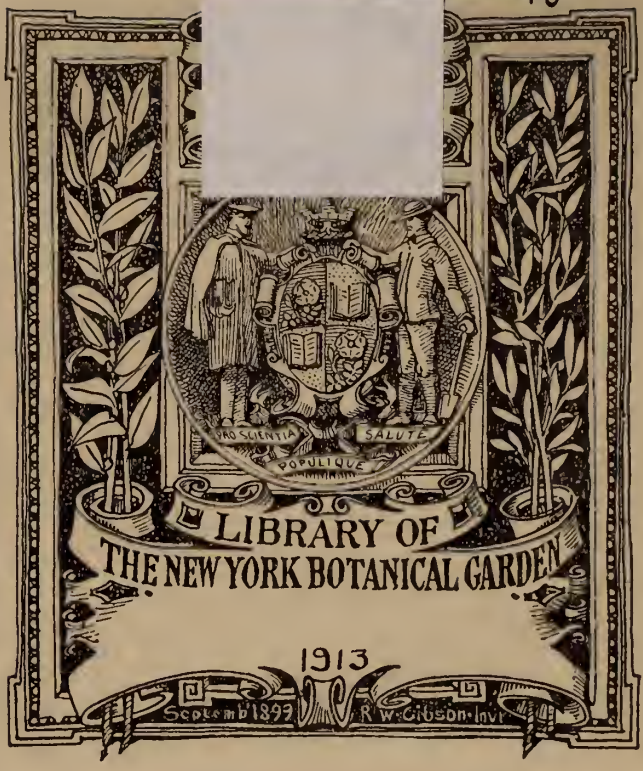
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MYCOLOGIA

IN CONTINUATION OF THE JOURNAL OF MYCOLOGY

Founded by W. A. Kellerman, J. B. Ellis, and B. M. Everhart in 1885

EDITOR

WILLIAM ALPHONSO MURRILL

Volume V, 1913

With 33 Plates and 1 Figure

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WILLIAM ALPHONSO MURRILL

Vol. V—JANUARY, 1913—No. 1

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ILLUSTRATIONS OF FUNGI.

MYCOLOGIA

VOL. V JANUARY, 1913 NO. 1

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ILLUSTRATIONS OF FUNGI—XIII

WILLIAM A. MURRILL

The accompanying plate illustrates several species of boletes collected either near Bronx Park, New York City, or in the vicinity of Stockbridge, Massachusetts. These are fleshy fungi with tubes instead of gills, usually occurring on the ground in woods during late summer and autumn. They are difficult to distinguish, even in the fresh state, and when the large amount of water they contain is eliminated the dried specimens bear little resemblance to the originals.

Many of the best edible fungi in temperate regions belong to this group, and the dangers of being poisoned are relatively small. Species with bitter or otherwise objectionable taste should be avoided, and especially all plants having red or reddish tube-mouths. The sensitive bolete, which promptly turns blue when touched or broken, has also caused mild poisoning in some cases. Many species have not been thoroughly tested, however; hence it is wise to eat sparingly of all such plants until well known.

For a complete treatment of the Boletaceae known to occur in this country, the student is referred to NORTH AMERICAN FLORA, volume 9, part 3, where the species are fully described and arranged under eleven genera with specific keys.

Gyroporus castaneus (Bull.) Quél.

CHESTNUT-COLORED GYROPORUS

Plate 80. Figure 1. × 1

Pileus convex to subexpanded, slightly depressed, gregarious,

[MYCOLOGIA for November, 1912 (4: 289–349) was issued November 23, 1912]

JAN 1 [illegible]

3–7 cm. broad; surface smooth, dry, minutely but densely tomentose, orange-brown, fulvous, or reddish-brown; margin thin, usually paler; context white, firm, nutty in flavor, unchanging when wounded; tubes depressed, sinuate, short, watery-white becoming light-yellow to dark-cremeous, mouths angular, small, stuffed when young, edges thin, entire; spores ellipsoid, smooth, hyaline to pale-yellowish, 8–9 × 4.5–5.5 μ; stipe subattenuate above and below, cylindric or somewhat flattened, tomentose, bright-brown, lighter at the apex, brittle, loosely stuffed, with a small cylindric cavity at the center, 4–5 cm. long, 6–10 mm. thick.

This species is common in Europe and the United States in sandy soil at the edges of woods. It is rather small, and varies in color from orange-brown to chestnut; the flesh is white, unchanging, of mild flavor, and edible.

Ceriomyces auriporus (Peck) Murrill

GOLDEN-PORED CERIOMYCES

Plate 80. Figure 2. × 1

Pileus circular, plano-convex, 2–4 cm. broad, 0.5–1 cm. thick; surface reddish-brown or yellowish-brown, rarely grayish-brown, sometimes brown with a reddish-yellow tint or reddish-brown in the center and olivaceous toward the margin, glabrous or minutely tomentose, slightly areolate at times with age, the interstices appearing yellow, usually dry, but somewhat viscid in wet weather; margin even, thin, somewhat obtuse, slightly inflexed on drying, concolorous; context firm, fleshy, 3–5 mm. thick, white, unchangeable, tinged with red under the cuticle, at first mild, then unpleasant to the taste, the cuticle decidedly acid; tubes plane or convex, adnate or nearly free, with a broad shallow depression about the stipe, 3–5 mm. long, bright golden-yellow, unchanging, even after years in the herbarium, mouths concolorous, variable in size, small and circular when young, medium or large and irregularly polygonal when old, edges thin, entire; spores oblong-ellipsoid, curved at one end, lemon-yellow, 8–10 × 4–5 μ; stipe central, short, slender, curved, tapering upward, nearly glabrous, pulverulent under a lens, slimy in wet weather, concolorous or paler, slightly striate above from the decurrent edges of the tubes, solid, white or discolored-yellowish tinged with red within, 2–4 cm. long, 4–8 mm. thick.

Common in thin, dry woods and on shaded roadsides from New England to Alabama, and readily distinguished by its beautiful

golden tubes, which remain for years after drying without changing color.

Rostkovites granulatus (L.) P. Karst.

GRANULATED ROSTKOVITES

Plate 80. Figures 3, 4. × 1

Pileus subhemispheric to nearly plane, gregarious, rarely cespitose or solitary, 4–10 cm. broad, 1–1.5 cm. thick; surface very viscid, with easily separable cuticle, very variable in color, usually pinkish-gray to reddish-brown fading to yellowish, often obscurely spotted, especially at the center; margin sterile, projecting, incurved and somewhat appendiculate when young; context thick, compact, elastic, pale-yellow next to the tubes, white above, unchanging when wounded, taste mild, somewhat mucilaginous; tubes short, less than 5 mm., adnate, subdecurrent, plane in mass, pale-yellow to dirty-yellowish, unchanging when wounded, mouths simple, subcircular, irregular, edges rather thick, flecked with pinkish-brown glandules; spores fusiform, pale-yellowish-brown, 7.5–9.5 × 2.5–3.5 μ; stipe short, thick, subequal or enlarged below, white or pale-yellow, dotted with pinkish-brown droplets which become darker on drying, solid, white within, 2.5–5 cm. long, 1–1.5 cm. thick.

Common in Europe and temperate North America, usually in open woods near coniferous trees. The figures show the more usual reddish-brown form, as well as the albino form, of this excellent edible species.

Rostkovites subaureus (Peck) Murrill

Boletus americanus Peck

GOLDEN ROSTKOVITES. AMERICAN BOLETUS

Plate 80. Figure 5. × 1

Pileus thin, convex to expanded, sometimes umbonate, 5–10 cm. broad; surface very viscid, yellow, often dotted or streaked with bright-red, dingy with age, sometimes spotted from the drying of the gluten; margin slightly tomentose or appendiculate when young; context comparatively thick, fleshy-tough, pale-yellow, pinkish-gray when wounded, taste mild; tubes adnate, scarcely decurrent, plane in mass, bright-yellow to dull-ochraceous flecked with yellowish, exuding drops which blacken with age, mouths rather large, angular, edges obtuse; spores oblong-ellip-

soid, smooth, ochraceous-ferruginous, 8.5–11 × 4–5 μ; stipe slender, tapering upward, yellow, darker toward the base, covered with numerous brownish or reddish-brown glandular dots which blacken with age, solid, yellow within, 4–7 cm. long, 4–8 mm. thick.

This species resembles the preceding and occurs in similar localities, but is confined to eastern North America. The specimens figured did not show the incarnate dots or streaks which often appear on the cap, affording a good distinguishing character. *Boletus flavidus* Fries, of Europe, is closely related.

Ceriomyces subglabripes (Peck) Murrill

SCURFY-STEMMED CERIOMYCES

Plate 80. Figure 6. × 1

Pileus circular, rather thin, subconic or convex to nearly plane, occasionally cespitose, 3–10 cm. broad; surface glabrous, subviscid when moist, rugose at times, usually so when dry, reddish, pale-chestnut, grayish-brown, golden-brown, or rarely darker-brown, margin regular, concolorous; context white or whitish, unchangeable, of mild flavor; tubes plane or convex, adnate or depressed, lemon-yellow, becoming greenish-yellow or darker from the maturing spores, mouths circular to angular, regular, rather small, edges entire; spores oblong-fusiform, greenish-brown when fresh, soon changing to ochraceous-brown, 12–15 × 4–5 μ; stipe central, cylindric, equal or slightly tapering upward, light-yellow without and within, sometimes tinged with red near the middle or lower down, striate but not reticulate, ornamented with small, pallid, scurfy particles, which sometimes partially disappear with age, 5–7 cm. long, 8–15 mm. thick.

On the ground in rather thick deciduous woods from Nova Scotia to New York. It was impossible to reproduce in the illustration the small scurfy particles on the stem which suggested the specific name. The section shows the usual smooth form of the cap, while the other figure represents the exceptional rugose form.

Ceriomyces bicolor (Peck) Murrill

TWO-COLORED CERIOMYCES

Plate 80. Figure 7. × 1

Pileus somewhat irregular, firm, convex, 5–10 cm. broad; surface dry, glabrous or finely tomentose or squamulose, at times

rimose-areolate with age, apple-red or purplish-red, often fading or becoming stained with yellow when old, margin irregular, sometimes upturned; context flavous, changing slowly to blue at times when wounded, then back to flavous, taste mild; tubes short, adnate, nearly plane, flavous when young, becoming ochraceous with age, changing slowly to blue or greenish-blue when wounded, mouths angular, of medium size, 2–3 to a mm.; spores fusiform, smooth, pale-ochraceous-brown, 10–12 × 4–5 μ; stipe nearly equal, firm, solid, yellow or red, sometimes slightly reticulate at the top, changing to greenish-blue when bruised, smooth, nearly glabrous, showing dark dots under a lens, solid, flavous within, changing slowly to blue, 4–10 cm. long, 0.7–1.5 cm. thick.

This very beautiful species may be looked for in open deciduous woods from New England to North Carolina and west to Ohio and Kentucky. The pileus is red or purple, lacking the bloom found in *C. Peckii,* the tubes are yellow, soon changing, and the stipe is yellow or red, without the distinct reticulations found both in *C. Peckii* and *C. speciosus.* The larger plant figured represents the stage in which the bright colors found in young specimens have somewhat faded.

NEW YORK BOTANICAL GARDEN

THE GENUS KEITHIA

ELIAS J. DURAND

(WITH PLATE 81, CONTAINING 11 FIGURES)

Dr. J. J. Davis has been good enough to place in my hands for study material of a discomycetous fungus parasitic on *Thuja,* which was collected by him in Wisconsin. It was first found July 14, 1908, at Mellen, Ashland Co., about twenty-five miles from Lake Superior, where, at two points along Bad River, *Thuja* was found bearing the fungus but not very abundantly. In July, 1909, the fungus was again met with in Oconto Co., in the Green Bay district, where it was very abundant on the same host. It seems probable, therefore, that the parasite is rather widely distributed in the northern part of Wisconsin.

Examination of the fungus showed its affinities to be with the genus *Keithia* Sacc., and it was named provisionally *K. thujina* Durand.[1] At that time I had not seen specimens of *K. tetraspora,* a European form, the typical and only described species of the genus. More recently, however, authentic material of that and of another allied species has become available which enables me to present the following account of this little-known parasitic group.

The genus *Keithia* was established by Saccardo[2] to include the single species described as *Phacidium tetrasporum* Phil. & Keith,[3] a parasite of *Juniperus,* in Scotland. The genus was referred to the Phacidiaceae, from the other members of which it differed in its 4-spored asci, and its colored spores divided by a single septum into two unequal cells. Authentic specimens of *Phacidium tetrasporum* collected at Forres, Scotland, June, 1880, by Rev. J. Keith, now in the New York State Museum of Natural History, at Albany, have been examined. A related species parasitic on *Tsuga,* in New Hampshire, was described by Dr. Farlow, in 1883,

[1] Trans. Wisc. Acad. Sci. Arts Let. 16: 756. 1909.

[2] Syll. Fung. 10: 49. 1892.

[3] Gardeners' Chronicle, N. S. 14: 308. 1880.

under the name *Stictis Tsugae.*[4] Examination of authentic material has shown it to belong in *Keithia* rather than in either *Stictis* or *Propolidium,* to which it was referred by Saccardo. The genus *Keithia,* therefore, is known to possess three species, all of which are parasitic on the leaves of conifers. One is on *Juniperus,* in Europe, the others on *Tsuga* and *Thuja,* respectively, in America.

Phillips and others have referred the parasite of juniper to the Phacidiaceae on account of its dark color, and its supposed laciniate method of dehiscence. Maire and Saccardo in describing the genus *Didymascella* (later regarded by Maire as a synonym of *Keithia*) remarked that it certainly belongs nearest to the Phacidiaceae. So long as knowledge of the genus was confined to the originally described species such a reference seems not at all remarkable. Further study of the group, especially of the two American representatives, throws a somewhat different light on its affinities, and seems to indicate that it might better be referred to the Stictidiaceae. Maire has pointed out, with good reason, that in the case of *K. tetraspora* the fungus itself does not split in a laciniate manner, but that the lobes are really formed of the epidermis of the host, which is ruptured by the expanding ascoma beneath.

There seems little room for doubt that the three species here included in *Keithia* are congeneric. The habit, all being parasites of coniferous leaves; the erumpent ascomata bursting the epidermis only; the uniformity of structure of the poorly developed excipulum; the small number and peculiar septation and color of the spores, all indicate that we are dealing with a very compact group. Comparison of these three species shows that in the case of *K. thujina* and *K. Tsugae* the color is much brighter than in *K. tetraspora,* and the covering epidermis is thrown off as a scale rather than splitting stellately. When completely moist the ascoma becomes somewhat elevated and cushion-like. The general resemblance of these plants to *Propolis faginea* is so great that it seems that they must be associated in the same family. Sections show that in all species of *Keithia* the excipulum and hypothecium are very poorly developed, but certainly are not lacking as stated

[4] Appalachia 3: 245. 1883.

in the description of *Didymascella*. The substance of the ascoma is soft and waxy when fresh. On the basis of these characters I believe that the affinities of *Keithia* are not with the Phacidiaceae, with which European authors have associated it, but with the Stictidiaceae, to which the parasite on *Tsuga* was originally referred by Dr. Farlow. If this disposition is the correct one we have in *Keithia* a genus of strictly parasitic fungi in a family otherwise almost exclusively saprophytic.

The genus may be characterized as follows:

A genus of the Stictidiaceae parasitic on leaves of conifers. Ascomata erumpent, rupturing the epidermis either laciniately or in the form of a scale, bright-colored to dark. Spores 2 or 4, becoming olive-brown, divided into two unequal cells by a septum near one end.

SYNOPSIS OF SPECIES

Spores 4 in each ascus.	
Epidermis ruptured laciniately, on *Juniperus*.	1. *K. tetraspora*.
Epidermis ruptured in the form of a scale, on *Tsuga*.	3. *K. Tsugae*.
Spores 2 in each ascus, epidermis rupturing by a scale, epispore punctate, on *Thuja*.	2. *K. thujina*.

1. KEITHIA TETRASPORA (Ph. & Keith) Sacc. Syll. **10**: 49. 1892

Phacidium tetrasporum P. & K. Gard. Chron. N. S. **14**: 308. 1880.

Didymascella Oxycedri Maire & Sacc. Ann. Myc. **1**: 418. 1903 (fide Maire, Bull. Soc. Myc. Fr. **21**: 140. 1905).

Hypophyllous, erumpent, ascomata at first buried beneath the epidermis, then breaking through and rupturing the epidermis by 3–4 laciniae, seated in the midst of a small, circular, yellowish-brown spot; the pustule elliptical, .75–1 mm. long, .5 mm. wide; disk brownish-black. Asci clavate, 175 × 16–18 μ, apex rounded, not blue with iodine. Spores 4, uniseriate, at first hyaline, later becoming olive-brown, ellipsoid to piriform-ellipsoid, the smaller end occasionally prolonged to form a short beak-like projection, divided by a septum close to one end into two very unequal cells, the smaller being as often distal as proximal, 21–24 × 13–16 μ. Paraphyses cylindric, hyaline below, septate, 2–3 μ thick, the apex clavate, olive-yellow, 8–9 μ thick.

On living leaves of juniper (*J. communis*, probably), Forres, Scotland, 1880, Rev. J. Keith.

Phillips described the fungus as occurring on the upper side of the leaf, but in the twenty-five or more infected leaves examined it is hypophyllous without exception. I have seen no reference to other collections of this species before 1903. In that year a parasite of *Juniperus Oxycedrus,* from Corsica, was described under the name *Didymascella Oxycedri,* by Maire and Saccardo. I have not seen specimens of this fungus, but Maire, following the suggestion of Patouillard, later came to the conclusion that it does not differ from *Keithia tetraspora.*

The erumpent ascomata remind one strongly of the pustules of some *Puccinia.* Sometimes as many as three ascomata may appear on a single leaf of the host. The spores are quite similar to those of *K. thujina,* but there are four in each ascus, the septum is not quite so close to one end, and the walls are not pitted. The laciniate rupturing of the epidermis is distinctive, as well as the dark color of the hymenium.

2. **Keithia thujina** sp. nov.

Ascomata epiphyllia, erumpentia, orbicularia vel elliptica, pulvinata, olivacea vel brunneo-olivacea, 1–1.25 mm. longa, .5 mm. lata; epidermis supra integra non laciniatim decidens. Asci clavati, 80–100 × 18–20 μ. Sporae duae, brunneo-olivascentes, elliptico-piriformes, septo ad apicem anteriorem inaequaliter divisae, punctatae, 22–25 × 15–16 μ. Paraphyses furcatae, septatae, clavato-incrassatae, olivaceae.

Ascomata epiphyllous, erumpent, at first buried beneath the epidermis which is lifted up, breaks around the margin, and finally falls away as an entire flap or scale, exposing the ascoma in the form of a cushion-like elevation. Ascomata circular to elongate-elliptic in outline, straight or curved, convex above, having the form of depressed cushions which are raised slightly above the surface of the substratum, .5 mm. broad, up to 1.25 mm. long; disk olive to olive-brown. Asci clavate, stout, 80–100 × 18–20 μ, opening by a pore, not blue with iodine. Spores 2, placed end to end, at first hyaline, finally becoming olive-brown, broadly ellipsoid or piriform-ellipsoid, the smaller end uppermost, at first continuous, finally divided by a single transverse wall close to the distal end into two very unequal cells, epispore with minute pits over its whole surface, 22–25 × 15–16 μ. Paraphyses branched below, septate, strongly clavate-thickened in the distal third, cohering, somewhat longer than the asci, 2–3 μ thick below, 5–8 μ thick above, olive.

On living leaves of *Thuja occidentalis,* Mellen, Wisc., 14 July, 1908 (Durand no. 6259, type); Oconto Co., July, 1909 (Durand no. 6910), *Dr. J. J. Davis.*

This species differs from *K. tetraspora* in the 2-spored asci, pitted spores, olive hymenium and the method of rupturing the covering epidermis. The fungus attacks the young, living foliage so that the scale-like leaves turn brown and die. In old specimens the ascomata fall out, leaving a hole extending nearly through the leaf. The septum in the spore is not always evident with low or medium powers of the microscope, but comes out best under an oil immersion objective. The same is true of the markings of the epispore, which consist of minute pits extending about half way through the wall. Such pit-like markings are quite unique in either the Phacidiaceae or Stictidiaceae.

The parasite does not seem to have any visible effect on the vigor of the tree, according to Dr. Davis's observations, since it destroys only a limited amount of leaf-tissue. Experience with other fungous diseases, however, leads one to suspect that under favorable conditions, or in certain seasons, it might become serious.

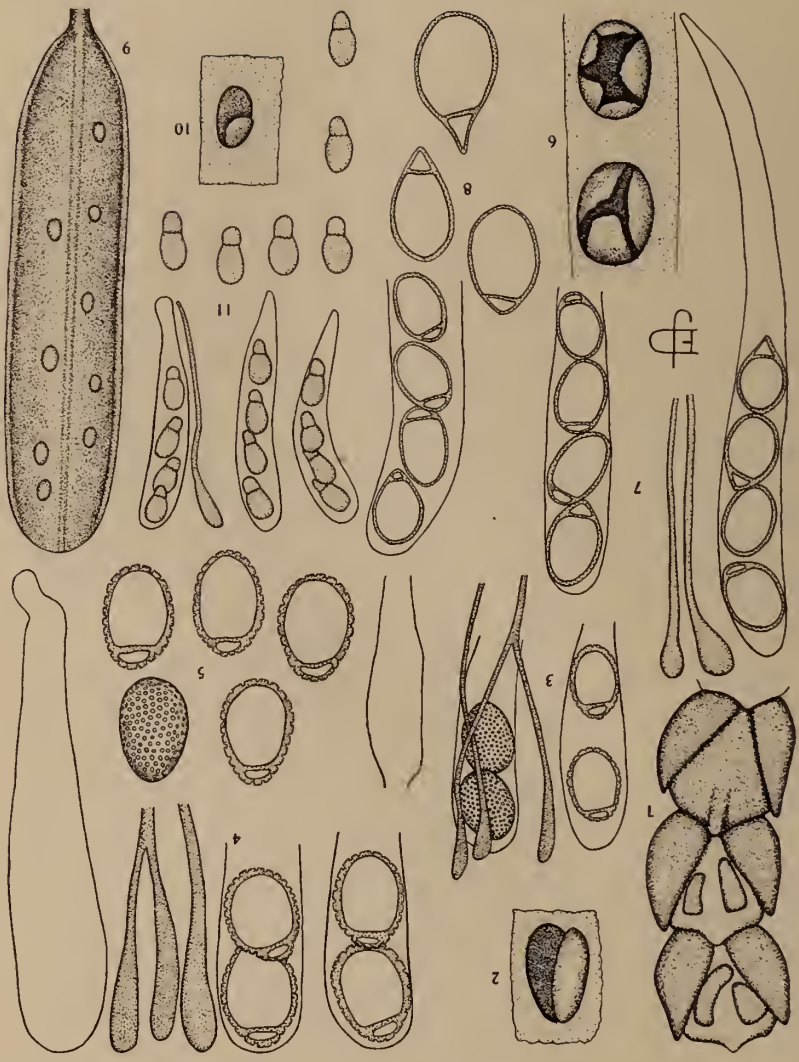
3. **Keithia Tsugae** Farlow

Stictis Tsugae Farlow, Appalachia 3: 245. 1883.
Propolidium Tsugae (Farlow) Sacc. Syll. Fung. 8: 668. 1889.

Hypophyllous, numerous, scattered; ascomata minute, at first buried beneath the epidermis which is finally ruptured and turned to one side as a scale, becoming more or less elevated and cushion-like, dark brown, orbicular to elliptic, .3–.5 mm. in diameter. Asci oblong-clavate, apex rounded, not blue with iodine, 58–65 $\times$ 13–16 μ. Spores 4, uniseriate, at first hyaline, finally becoming greenish brown, ellipsoid-ovoid, divided by one septum into two unequal cells of which the proximal is smaller, constricted at the septum, 13–16 $\times$ 6–8 μ, smooth. Paraphyses cylindric, septate, hyaline below, the tips clavate, olive-brown, 4–5 μ thick.

On living and dead leaves of *Tsuga canadensis.* New Hampshire: Shelburne and Lake Sunapee, July–Sept., *Dr. W. G. Farlow;* Wisconsin: Price Co., 13 Sept., 1911, *Dr. J. J. Davis.*

I have examined a portion of the type of this species kindly placed at my disposal by Dr. Farlow, as well as other specimens from his collection in the herbarium of the New York Botanical



1–5. KEITHIA THUJINA Durand

6–8. KEITHIA TETRASPORA (Ph. & Keith) Sacc.

9–11. KEITHIA TSUGAE Farlow

Garden. The material from Lake Sunapee is more mature than the rest, and shows spores conspicuously colored. This character, as well as the tetrasporous asci and the spores divided into two very unequal cells, indicates its close relationship to *K. tetraspora* and *K. thujina.* The covering epidermis falls as a scale as in the last named species.

Dr. Davis's recent collections are also mature and agree in all respects with those from New Hampshire.

Dr. Farlow informs me that since he first found it, in 1882–3, he has secured more mature material in several localities, which has quite modified his original view regarding this species. In the type the spores are immature and hyaline, and through an error were described as 8-spored instead of 4-spored. Comparison with authentic *Keithia tetraspora,* in Europe, convinced him that his *Stictis Tsugae* is congeneric, and should be called, therefore, *Keithia Tsugae.*

The same writer speaks of the parasitism of this species as follows: "The fungus appears only on the under side of the leaves, which turn brown and quickly fall. It was first noticed in August, 1882, on a tree affected with *Peridermium Peckii.* In September, 1883, it was found on a large number of trees, and had nearly destroyed the foliage. It may be considered a disease which does considerable harm."

On the basis of observations recently made upon this species in Wisconsin, Dr. Davis entertains some doubts about its parasitic nature. He has found no instances in which it appeared on undoubtedly living leaves, and he is convinced that it is not so certainly parasitic as is *K. thujina.*

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EXPLANATION OF PLATE LXXXI

Keithia thujina. Fig. 1. Portion of branch of *Thuja* showing four ascomata. × 6. Fig. 2. Single ascoma much enlarged showing the epidermal scale falling away. Fig. 3. Asci, paraphyses and spores. Figs. 4–5. Asci, paraphyses and spores drawn with the oil immersion objective.

Keithia tetraspora. Fig. 6. Portion of leaf of *Juniperus* showing two ascomata exposed by the stellate splitting of the epidermis. Fig. 7. Three asci, paraphyses and spores. Fig. 8. Three spores more highly magnified.

Keithia Tsugae. Fig. 9. Leaf of *Tsuga* showing nine ascomata, much enlarged. Fig. 10. Single ascoma greatly enlarged exposed by falling epidermal scale. Fig. 11. Asci, paraphysis and spores.

TYPE STUDIES IN THE HYDNACEAE[1]
III. THE GENUS SARCODON

Howard J. Banker

The name *Sarcodon* was first proposed by Quélet in Cooke and Quélet, Clav. Syn. Hym. Eur. 195. 1878, but as no binomials were formed the name was not established as a genus until later taken up by Karsten. Whether we follow Quélet or Karsten in our conception of the genus, the type species is *Hydnum imbricatum* L.

Sarcodon reticulatus Banker, Mem. Torrey Club **12**: 139. 1906

Hydnum fragile Fries, Nya Svamp. in Ofvers. af Kongl. Vetensk. Ak. Forhandl. **1851**: 53. 1852; not *H. fragile* Persoon, Syn. Meth. Fung. 561. 1801.

The type of this species is "Copp 3716" deposited in the New York Botanical Garden herbarium. The specimen was collected in Iona, New Jersey, and is a part of the only collection of the species made in this country. Specimens of the plant sent to M. C. Cooke were referred by him to *Hydnum fragile* Fr. The Friesian name is untenable as it is preoccupied by *H. fragile* Pers. applied to a resupinate form. No type of *H. fragile* Fr. was found at Upsala, but European plants apparently identical with the American form are uniformly referred there to *H. fragile* Fr. At Kew specimens were found, collected in England, identical in every respect with the New Jersey plants even to the adherence of pine needles to the pileus indicating a similar habitat. At Upsala there was found a specimen collected at Mustiala, Finland, by P. A. Karsten, that had all the characters of our type except that it had a long somewhat fusiform stem, 2×8 cm., raising the pileus well up from the earth. This feature has not been observed in any other specimens.

[1] Investigation prosecuted with the aid of a grant from the Esther Herrman Research Fund of the New York Academy of Science.

SARCODON ACRE Quélet, Ench. Fung. 188. 1886

Hydnum acre Quélet, Bull. Soc. Bot. France 24: 324. *pl. 6. f. 1.* 1877.

Hydnum cristatum Bres. Atkinson, Jour. Myc. 8: 119. 1902.

The type of *H. acre* Quél. has not been seen. A specimen, however, has been received from G. Bresadola which that eminent mycologist had compared with Quélet's type and regards as an authentic representative of the species. This specimen does not appear to me to differ in any respect from authentic specimens of *Hydnum cristatum* Bres., received from Professor George F. Atkinson, which are a part of the type collection. The acrid taste noted in both the European and the American plants confirms the diagnosis of their identity, as this character is not common in the Sarcodons. A specimen at Kew contributed by Quélet has all the characters of our American forms. There seems to be no good reason to maintain *H. cristatum* Bres. as a distinct species.

The plant appears to be most abundant in Connecticut and Long Island.

Sarcodon radicatus sp. nov.

Sarcodon fuligineo-violaceus Banker, Mem. Torrey Club 12: 142. 1906; not *Sarcodon fuligineo-violaceus* (Kalch.) Quél. Ench. Fung. 189. 1886.

Hymenophore terrestrial, mesopodous, gregarious, small, 3–4 cm. high, brownish; pileus subconvex, uneven, somewhat irregular, 4–6 cm. wide; margin thin, sterile, decurved; surface subpubescent to smooth, sometimes with small innate scales, light-brown or ochraceous-brown with darker areas; substance fleshy, somewhat tough, light-brown, lighter than the surface; stem subflexuose, somewhat inclined, excentric to central, solid, subeven, abruptly narrowing below to a slender root-like base, 2–2.5 cm. long, 1–1.5 cm. wide; teeth fine, terete, tapering, decurrent more or less scatteringly to the base, seal-brown to flesh color at the tips, when dry a uniform tawny-brown, short teeth scattered about among the long, 1.5–2 mm. long, 0.1–0.2 mm. wide, 9–12 to a square mm.; spores subglobose, tuberculate, 4–5.5 μ wide, brown; hyphae of trama hyaline, smooth, thin-walled, collapsing when dried, recovering slightly in KOH, forming an intricate tangle, scarcely separable in KOH, septate, without clamp-connections, segments irregular, more or less inflated, 9–12 μ wide, 40 μ or more long; taste mild; odor of slippery elm.

On earth in mixed woods, late summer and autumn, Schaghticoke, N. Y.

The type of the above described species is in the writer's herbarium. This species is distinct from *Hydnum fuligineo-violaceum* Kalch., although Kalchbrenner's *Hydnum fuligineo-violaceum,* though not with entire confidence. Since then specimens have been received from Abbate G. Bresadola which that distinguished mycologist collected in Trient and compared with Kalchbrenner's type. These plants are manifestly very different from the American forms described above. At Upsala two specimens were observed collected in Hungary and contributed by Kalchbrenner himself. These plants appeared to have the characters of Bresadola's specimens, but were smaller, approaching in size the American plants. They confirmed the diagnosis that the above described species is distinct from *Hydnum fuligineo-violaceum* Kalch., although Kalchbrenner's figure[2] closely resembles the appearance of our plants.

SARCODON LAEVIGATUS (Sw.) P. A. Karsten, Rev. Myc. 3[1]: 20. 1881

Hydnum laevigatum Sw. Kongl. Vetensk. Acad. Handl. 1810: 243. 1810.

Hydnum bubalinum Pers. Myc. Eur. 2: 161. 1825.

There is probably no type of *H. laevigatum* Sw. in existence. At least I have not been able to locate any of Swartz's specimens. In the European herbaria very little material was found referred to this species and none that could be regarded as having much weight in determining the authentic characters of the species. The American plants which we have referred to this species conform well to the few European plants that we have seen and appear to have all the characters ascribed to the species.

Hydnum bubalinum Pers. is represented in Persoon's herbarium at Leyden by a single specimen sent by Chaillet. The plant appears to be the same as our specimens of *H. laevigatum* Swartz.

SARCODON IMBRICATUS (L.) P. A. Karsten, Rev. Myc. 3[1]: 20. 1881

Hydnum imbricatum L. Sp. Pl. 2: 1178. 1753.

Hydnum cervinum Pers. Obs. Myc. 1: 74. 1796.

[2] Kalchbrenner, Icon. Hym. Hung. *pl. 32. f. 2.*

There is of course no type of *H. imbricatum* L. in existence. At Upsala a number of specimens of European plants, mostly from Scandinavia and Finland, were found referred to this species by Fries, Karsten, and others. These were uniform in character and most closely resembled the large coarse-scaled American forms as figured by F. E. Clements, Minnesota Mushrooms 104. *f. 69.*

No type of *H. cervinum* Pers. was found at Leyden, but from the description the species does not appear to be distinct from *H. imbricatum* L. and was so regarded by Persoon himself, see Syn. Meth. Fung. 554.

Sarcodon Murrillii sp. nov.

Hymenophore terrestrial, mesopodous, medium to large size, reddish-brown; pileus expanded to infundibuliform, subrotund to irregular, 5–10 cm. wide, 1–2 mm. thick when dried; surface roughened with fine floccose scales, coarsest toward center, 1–2 mm. wide, ends upturned, about as long as wide, subzonately arranged, dark-reddish-brown on scales, lighter between; margin thin, fertile, repand, finely lobed or crenate, pallid; substance fleshy, pale-brown to whitish, drying thin, but somewhat tough and flexible; stem subcentral, strongly inclined, tapering gradually and then abruptly to the base, reddish-brown above, concolorous with pileus, paler below but becoming blackish at the base, scabrous roughened nearly to the base, apparently hollow or stuffed, 4–6 cm. long, 1–2 cm. wide; teeth small, slender, terete, tapering, acute, crowded, decurrent nearly to the base, reddish-brown, white tipped, 1.5 mm. or less long in dried plant, 0.15–0.25 mm. wide, 9–12 to a square mm.; spores subglobose, tuberculate, tubercles not prominent, pale-brownish, 6–7 μ wide; basidia prominent, irregular, clavate, 8–10 μ wide; sterigmata conical, curved, horn-shaped, 3–4 μ long; hyphae of trama hyaline, smooth, thin-walled, collapsing when dried, recovering in KOH, subparallel but partly separable in KOH, septate, without clamp-connections, segments short, stout, constricted at the septa, irregular, 10–28 μ wide by 20–70 μ long; hyphae of the teeth very slender, tubular, rarely septate, 3–4 μ wide.

The type of the species is *Murrill and House 397*, Transylvania, North Carolina, deposited at the New York Botanical Garden.

Many of the specimens distributed in Ellis, N. Am. Fung., "926 Hydnum imbricatum" are undoubtedly this species. I know that some of them are.

Sarcodon fumosus sp. nov.

Hymenophore terrestrial, mesopodous, small, 3–5 cm. high, ash-gray to smoky; pileus plane to convex, 2–3 cm. wide, 2–3 mm. thick; surface even, subpubescent, ash-gray to smoky-olivaceous-brown when dried; margin thin, fertile, minutely serrate; substance fleshy-spongy when fresh, somewhat tough, flexible, compact, subwaxy toward surface, soft fibrous within, olivaceous, when dried; stem slender, subcentral, inclined or curved, attenuate upward, subpubescent at base to glabrous shining toward the cap, 2–4 cm. long, 3–10 mm. wide; teeth short, slender, terete, tapering, acute, uneven, not decurrent, pale to dirty-white, somewhat crowded, 2–5 mm. long or less, 0.2–0.4 mm. wide, 9–12 to a square mm.; spores dark, coarsely and densely tuberculate, ovoid, 7–9 μ × 9–11 μ wide; basidia clavate to oblong, narrowing abruptly at the base, 7–10 μ wide by 25–30 μ long; sterigmata delicate, conical, incurved, 3–4 μ long; hyphae of trama colored, dissolving out freely in KOH, becoming hyaline, slender, smooth, thin-walled, collapsing when dried, recovering slightly in KOH, forming an intricate tangle but slightly separable in KOH, septate without clamp-connections, segments extremely long, somewhat irregular, more or less constricted at the septa, 4–6 μ wide; hyphae of the teeth very slender, parallel, 3–4 μ wide; taste bitterish.

The type of the species is *Murrill and House 394*, North Carolina, deposited at the New York Botanical Garden.

Sarcodon roseolus sp. nov.

Hymenophore terrestrial, mesopodous, gregarious, small to medium size, 4–6 cm. high, pale-rose-color; pileus plane to convex, 3–4 cm. wide, 0.5 cm. or less thick; surface pubescent and slightly imbricate, scaly, even, whitish tinged with old-rose; margin thin, incurved when dried; substance fleshy-tough, drying into two layers, an inner waxy or gummy, subtranslucent layer, and an outer dry, opaque, subfibrous layer; stem slender, subcentral, strongly inclined, subeven, slightly radicating, scabrous, 2–3 cm. long by 7–10 mm. wide; teeth very short, terete, tapering, acute, uniform, decurrent and abortive on the stem, not crowded, 0.3–0.7 mm. long by 0.1–0.2 mm. wide, 16–20 to a square mm.; spores pale-brown, tuberculate, ovoid, 4–5 × 5–6 μ wide; basidia clavate, four-spored, 5–6 μ wide; sterigmata slender, capillary, 3 μ long; hyphae of inner portion of pileus clouded, smooth, slender, thin-walled, collapsing when dried, recovering in water and KOH, forming a somewhat intricate and compact tangle, scarcely sepa-

rable in KOH, septate, without clamp-connections, segments long, irregular, subtubular, 4–7 μ wide, contents granular; hyphae of outer portion of pileus more even, tubular, and coiled.

The type of this species is *Murrill and House 392*, North Carolina, in New York Botanical Garden. No other specimens are known.

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THE AGARICACEAE OF TROPICAL NORTH AMERICA—VI

William A. Murrill

The present article concludes the treatment of species with ochraceous or ferruginous spores begun in Mycologia for March, 1912. A portion of the generic key printed at that time appears below in a slightly revised form.

Volva and annulus absent.	
Pileus centrally stipitate.	
Lamellae adnate or decurrent.	9. Gymnopilus.
Pileus dimidiate or resupinate.	10. Crepidotus.
Volva absent, annulus present.	
Stipe glabrous or fibrillose.	11. Pholiota.
Stipe squarrose-scaly.	12. Hypodendrum.

9. Gymnopilus Karst. Hattsv. 400. 1879

Flammula (Fries) Quél. 1872. Not *Flammula* DC. 1818.

A difficult cosmopolitan genus, with fleshy or fibrous stipe, adnate or decurrent lamellae, and usually abundant bright-ferruginous spores. Most of the species occur on decayed wood.

1. **Gymnopilus olivaceus** (Pat.)

Flammula olivacea Pat. in Duss, Enum. Champ. Guad. 55. 1903.

Known only from type specimens collected by Duss on dead wood at Basse-Terre, Martinique.

2. **Gymnopilus vinicolor** (Pat.)

Flammula vinicolor Pat. Jour. de Bot. 3: 339. 1889.

Collected by Duss on dead wood at Saint Pierre, Martinique. Pileus 1–2 cm. broad, deeply umbilicate, glabrous, red tinted with wine-color; lamellae close, large, scarcely decurrent; spores ovoid, smooth, ochraceous, 6–7 × 3–4 μ.

3. **Gymnopilus lateritius** (Pat.)

Flammula lateritia Pat. Bull. Soc. Myc. Fr. **16**: 176. 1900.

Described from specimens collected by Duss on dead wood at Pointe-Noire, Guadeloupe. Also collected twice by Duss on *Psidium* at Calebasse, Martinique.

4. **Gymnopilus parvulus** sp. nov.

Pileus convex to nearly plane, subcespitose, reaching 2–4 cm. broad; surface moist but not viscid, flavous-ochraceous when young, becoming somewhat darker with age, decorated with conspicuous, erect, pointed scales or fibrils which are isabelline to fulvous in color; margin striate, undulate, incurved on drying; context thin, pale-ochraceous, slightly bitter; lamellae narrow, subcrowded, adnate, sometimes with a decurrent tooth, isabelline to ferruginous-fulvous; spores ellipsoid, nearly smooth, ferruginous, $6–7 \times 4\,\mu$; stipe stout, concolorous or darker, slightly blackish toward the base, especially on drying, fibrillose, solid, becoming hollow, rather fragile, 2–4 cm. long, 3–5 mm. thick; veil delicate, consisting of yellow fibrils, evanescent.

Type collected on a dead log at Castleton Gardens, Jamaica, October 28, 1902, *F. S. Earle 222*. Also collected near Port Antonio, Jamaica, December 17, 1908, *W. A. Murrill 182*, and in the Cockpit Country, Jamaica, January 12–14, 1909, *W. A. Murrill & W. Harris 939, 952*.

5. **Gymnopilus aureobrunneus** (Berk. & Curt.)

Flammula aureobrunnea Berk. & Curt. Jour. Linn. Soc. **10**: 289. 1868.

Described from Wright's collections in Cuba. Spores subglobose to broadly ellipsoid, smooth, $5–7 \times 3.5–4\,\mu$.

Cuba, *Wright 64;* Candelaria, Cuba, on a royal palm stump, *Earle & Wilson 202*.

6. **Gymnopilus aureoviridis** (Pat.)

Flammula aureoviridis Pat. in Duss, Enum. Champ. Guad. 55. 1903.

Described from specimens collected by Duss on dead wood at Camp Jacob, Guadeloupe.

7. **Gymnopilus helvoliceps** (Berk. & Curt.)

A. (*Flammula*) *helvoliceps* Berk. & Curt. Jour. Linn. Soc. **10**: 290. 1868.

Described from specimens collected by Wright in Cuba on rotten logs in woods. Said to be distinguished at once from *G. chrysopellus* by its much larger spores, which are oblong-ellipsoid, smooth or slightly punctate, ferruginous, 9–12 × 5 μ. Duss reports the species from Guadeloupe and Martinique. Specimens from South Carolina placed in this category at Kew are incorrectly determined.

8. GYMNOPILUS PENETRANS (Fries) Murrill, Mycologia 4: 254. 1912

Described from Sweden in 1815, and reported from Cuba and Australia. The only tropical specimens I have seen that appear to fit the species are those cited below, which indicates that it has crossed over from the mainland.

Troy and Tyre, Cockpit Country, Jamaica, *Murrill & Harris 875, 1035.*

9. **Gymnopilus subpenetrans** sp. nov.

Pileus broadly convex to expanded, rather thick, 2–4 cm. broad; surface moist, not viscid, slightly fibrillose, ferruginous-orange, margin rather thick, not striate; context whitish, mild but unpleasant to the taste; lamellae sinuate with a long-decurrent tooth, soon separating from the stipe; spores ellipsoid, punctate or nearly smooth, ferruginous, 8–10 × 4–5 μ; stipe slightly tapering downward, concolorous, not paler below, somewhat fibrillose, solid with spongy interior, about 3 cm. long and 3 mm. thick.

Type collected on a dead royal palm trunk at Managua, Cuba, May 25, 1906, *C. F. Baker* (*Earle 526*). Also collected on dead wood in the Cockpit Country, Jamaica, January 12–14, 1909, *W. A. Murrill & W. Harris 922.*

10. **Gymnopilus depressus** sp. nov.

Pileus convex to deeply depressed, gregarious or cespitose, reaching 8–10 cm. broad; surface dry, densely floccose-scaly, becoming subglabrous, dull-yellowish, at length dull-rusty-brown,

margin not striate, strongly inflexed on drying; lamellae short-decurrent, subdistant, broad, yellow to ferruginous; spores ellipsoid, minutely punctate, ferruginous, $7 \times 4\,\mu$; stipe subcylindric, slightly enlarged at the apex and base, slightly paler than the pileus, yellowish above, minutely scaly-fibrillose throughout, fleshy, yellow within, solid when young, becoming fistulose with age, 4–8 cm. long, 6–10 mm. thick; veil delicate, consisting of yellow fibrils, evanescent.

Type collected on a dead log in Hope Gardens, Jamaica, November 16, 1902, *F. S. Earle 499.*

11. **Gymnopilus chrysotrichus** (Berk. & Curt.)

A. (*Flammula*) *chrysotrichus* Berk. & Curt. Jour. Linn. Soc. 10: 290. 1868.

Described from specimens collected by Wright in Cuba on dead logs in fields. The spores are subglobose to broadly ellipsoid, finely echinulate, melleous under a microscope, $5–7 \times 4\,\mu$. Duss also reports the species from Guadeloupe and Martinique, and his specimens at Berlin appear to be correctly determined.

Cuba, *Wright 26, 54;* Guadeloupe, *Duss 55;* Martinique, *Duss 1258.*

12. **Gymnopilus chrysotrichoides** sp. nov.

Pileus thick, fleshy, convex to subexpanded, gregarious, reaching 7 cm. broad; surface dry or moist, not viscid, glabrous, ferruginous to fulvous, margin entire, concolorous, slightly sulcate with age, inflexed on drying; lamellae adnate with a decurrent tooth, broad, close, becoming ferruginous or fulvous; spores ellipsoid, punctate-tuberculate, ferruginous, $8–9 \times 5–6\,\mu$; stipe cylindric, equal, usually somewhat curved, pallid, glabrous, longitudinally furrowed, at least above, 4–6 cm. long, 3–6 mm. thick, decorated near the apex with the remains of a rather large membranous, yellowish, usually permanent veil.

Type collected on a dead cocoanut log near Managua, Cuba, October 2, 1904, *F. S. Earle 270.* Similar to *G. chrysotrichus* in appearance, but considerably larger, with larger spores, and a rather large veil which remains as a distinct annulus. The species might be assigned to *Pholiota* if its affinities were not so evidently with *Gymnopilus.*

13. **Gymnopilus Earlei** sp. nov.

Pileus rather thick, tough, convex to expanded, cespitose, 3–6 cm. broad; surface dry, fibrillose and floccose-squamose, pale-ferruginous; margin uneven, somewhat fluted, not striate; context mild to the taste, said to be edible when young; lamellae adnate or subdecurrent, rather broad, subcrowded, ferruginous, darker than the surface of the pileus; spores ellipsoid, ferruginous, conspicuously punctate, $7–8 \times 4–5\,\mu$; stipe cylindric, densely ferruginous-fibrillose, subconcolorous, solid, tough, horny, nearly black within, 4–6 cm. long, 4–8 mm. thick.

Type collected on cocoanut logs near Port Antonio, Jamaica, October 20, 1902, *F. S. Earle 9*. Reported by Earle to be common on cocoanut logs and stumps in the vicinity of Port Antonio, and said to be edible when young.

14. **Gymnopilus tenuis** sp. nov.

Pileus rather thin, convex to expanded, obtuse, cespitose, 3–10 cm. broad; surface pale-yellow to ferruginous, dry, fibrillose to floccose-scaly, at length subglabrous, margin thin, not striate, often uneven and undulate; lamellae decurrent, crowded, narrow, yellow to ferruginous; spores ellipsoid, ferruginous, minutely punctate, $7 \times 4\,\mu$; stipe cylindric, slightly fibrillose, ferruginous-brown, often whitish at the base, hollow, the rind becoming hard and horny on drying, 4–6 cm. long, 3–8 mm. thick; veil of bright-yellow fibers, soon vanishing.

Type collected on a dead log of *Nectandra* near Port Antonio, Jamaica, November 24, 1902, *F. S. Earle 612*. Also collected on a cocoanut log near Port Antonio, Jamaica, November 23, 1902, *F. S. Earle 594;* on dead wood on Cooper's ranch at the base of El Yunque, near Baracoa, Cuba, March, 1903, *L. M. Underwood & F. S. Earle 1136;* and at Soldier's Road, New Providence, Bahamas, September 15, 1904, *E. G. Britton 699*. Broad and thin, with narrow, crowded lamellae and minutely punctate spores.

15. **Gymnopilus bryophilus** sp. nov.

Pileus convex, obtuse, gregarious, 2–5 cm. broad; surface uniformly ferruginous, dry, densely appressed-fibrillose, margin not striate; lamellae sinuate with a decurrent tooth, crowded, plane, broad, concolorous; spores subglobose, smooth, pale-ferruginous, $6 \times 5\,\mu$; stipe cylindric, often eccentric, fibrillose, pale-fuscous, fleshy, solid, yellow within, 2–4 cm. long, 3–4 mm. thick.

Type collected on a decayed mossy log near Port Antonio, Jamaica, November 24, 1902, *F. S. Earle 613*. Distinguished by its densely fibrillose pileus and smooth, subglobose spores.

16. **Gymnopilus chrysopellus** (Berk. & Curt.)

A. (*Flammula*) *chrysopellus* Berk. & Curt. Jour. Linn. Soc. 10: 290. 1868.

Described from Wright's collections on dead wood in Cuba. Spores broadly ellipsoid, often nearly subglobose, smooth, melleous under a microscope, 6–7 × 4–5 μ. Specimens bearing this name at Berlin, collected by Duss at Bains-Jaunes, are too badly discolored to be compared accurately.

17. **Gymnopilus Nashii** sp. nov.

Pileus convex, densely cespitose, 2–4 cm. broad; surface ochraceous, dry, densely floccose-squamose, margin not striate; lamellae adnate, subcrowded, broad, fuscous-ferruginous; spores ellipsoid, smooth, ferruginous, 7–7.5 × 4–5 μ; stipe subcylindric, enlarged at the apex, concolorous, darker below, fibrillose, firm, fleshy, becoming fistulose, 4–7 long, 3–6 mm. thick; veil pale-yellowish, scanty.

Type collected on an old log near Port Margot, Haïti, August 4, 1903, *G. V. Nash 79*. Also collected at Consuelo, Santo Domingo, November 15–17, 1909, *N. Taylor 177;* and at Sierra Nipe, Oriente, Cuba, January, 1910, *J. A. Shafer 3761*.

18. **Gymnopilus palmicola** sp. nov.

Pileus convex to expanded, at length depressed, cespitose, 2–5 cm. broad; surface dry, floccose-squamose, pale-ferruginous to ochraceous, margin even, not striate; lamellae adnate, subcrowded, broad, at length ventricose, ferruginous at maturity; spores ellipsoid, ferruginous, echinulate-punctate, 10 × 6 μ; stipe cylindric, slightly fibrillose, subconcolorous but paler, solid, fleshy, yellowish within, 3–5 cm. long, 3–5 mm. thick; veil strongly developed, pale-yellowish, subannulate.

Type collected on dead logs of royal palm on Cooper's ranch at the base of El Yunque, near Baracoa, Cuba, March, 1903, *L. M. Underwood & F. S. Earle 1134*. Similar to *G. lateritius* in microscopic characters, but the pileus is much lighter in color.

19. **Gymnopilus hispidellus** sp. nov.

Pileus thin, convex, scattered or subcespitose, 2–4 cm. broad; surface pale-ochraceous, fibrillose, often punctate-squamose with erect, ferruginous scales, margin not striate; context slightly bitter; lamellae adnate, subcrowded, not uniform in breadth, yellow to fuscous-ferruginous; spores ellipsoid, fuscous-ferruginous, strongly punctate, $7 \times 5\,\mu$; stipe cylindric, subfibrillose, concolorous with darker base, solid, 2–4 cm. long, 2–4 mm. thick; veil yellowish, subannulate.

Type collected on old logs on Cooper's ranch at the base of El Yunque, near Baracoa, Cuba, March, 1903, *L. M. Underwood & F. S. Earle 429.*

20. **Gymnopilus hispidus** (Mass.)

Flammula hispida Mass. Jour. Bot. **30**: 161. *pl. 323. f. 31–33.* 1892.

Described from specimens collected by W. R. Elliott on decayed trunks at Chateau Belair, St. Vincent, West Indies. The pileus is ochraceous-fulvous, and conspicuously adorned with erect, acute squamules; the lamellae are broad, subdecurrent, and crowded; and the spores ellipsoid, smooth, ferruginous, $7 \times 5\,\mu$.

21. **Gymnopilus areolatus** sp. nov.

Pileus thick, fleshy, convex, cespitose, 6–7 cm. broad; surface dry, imbricate-scaly, dirty-orange-yellow, margin entire; context yellowish-white, slightly bitter; lamellae adnate, separating from the stipe, subcrowded, broad, ventricose, often notched, yellowish-ferruginous; spores ellipsoid, ferruginous, tuberculate, 9–11 $\times$ 6–7 μ; stipe cylindric, often curved, concolorous or paler, subglabrous, solid, 3–5 cm. long, 4–6 mm. thick.

Type collected on a hardwood stump in a field near Santiago de las Vegas, Cuba, May 27, 1904, *F. S. Earle 36.* Also collected on a palm stump at the same time and place, *F. S. Earle 37;* and on the base of a palm post at Herradura, Cuba, September 27, 1907, *F. S. Earle 577.*

22. **Gymnopilus pholiotoides** sp. nov.

Pileus firm, fleshy, convex, scattered, 3 cm. broad; surface ochraceous, cracking into scales, margin thin, not striate; context

yellowish-white, mild to the taste; lamellae short-decurrent, crowded, of medium width, pale-ochraceous to bright-ferruginous; spores ellipsoid, conspicuously echinulate, ferruginous, $9 \times 5\,\mu$; stipe subcylindric, concolorous or paler, slightly fibrillose, solid, 3 cm. long, 5 mm. thick; veil thick, membranous, forming an annulus, at least in young sporophores.

Type collected on a dead royal palm trunk at Managua, Cuba, May 25, 1906, *C. F. Baker* (*F. S. Earle 527*). The young sporophores show a well-developed annulus, as in *Pholiota*.

23. GYMNOPILUS CARBONARIUS (Fries) Murrill, Mycologia 4: 256. 1912

A terrestrial species common throughout temperate North America and Europe. It was found in ashy ground by a burnt log, growing in groups or clusters. The elevation of Chester Vale is 3,000 ft., just sufficient to insure a subtemperate climate. The fondness of this fungus for charcoal is quite remarkable. For a description and colored figure of the species, see MYCOLOGIA for July, 1912.

Chester Vale, Jamaica, *W. A. & Edna L. Murrill 287*.

24. **Gymnopilus jalapensis** sp. nov.

Pileus expanded, at length depressed at the center, reaching 8 cm. in breadth; surface smooth, moist, glabrous, cremeous at the margin, ochraceous near the center and ferruginous-isabelline to fulvous at the center, slightly greenish when bruised; margin curved downward and irregular or undulate; context white, mild, 5 mm. thick behind; lamellae adnate, close, ventricose behind, arcuate near the margin, stramineous, about 5 mm. broad; spores ellipsoid, smooth, subhyaline but with a distinct ferruginous tint, $6 \times 3.5\,\mu$; cystidia abundant, flask-shaped, $60–75 \times 15\,\mu$, mostly empty and hyaline, with short stalks and long, slender, septate necks filled with yellowish contents; stipe equal below, slightly enlarged at the apex, glabrous, stramineous, with a trace of a slight cortina at the middle, reaching 8 cm. long and 1 cm. thick.

Type collected on the ground in leaf-mold in a dense virgin forest near Jalapa, Mexico, December 12–20, 1909, *W. A. & Edna L. Murrill 78* (*type*), *81*. The lamellae and spores are paler than in other American terrestrial species.

25. **Gymnopilus hypholomoides** sp. nov.

Pileus convex to expanded, 3–6 cm. broad; surface dry, subfibrillose, pale-fuscous, ferruginous at the center, margin thin, somewhat folded and uneven, not striate; context thin, yellowish, of mawkish flavor; lamellae inserted, crowded, rather narrow, sinuate, tawny-yellow to pale-fuscous; spores ellipsoid, fuscus, $7 \times 4\,\mu$; stipe cylindric, curved, concolorous, fibrillose, solid, tough, 4–6 cm. long, 2–4 mm. thick.

Type collected on the ground, apparently attached to buried wood, on Rose Hill, Jamaica, 3,000 ft. elevation, October 24, 1902, *F. S. Earle 53*. The surface of the cap resembles that of *Hypholoma sublateritium*.

DOUBTFUL SPECIES

Agaricus (*Flammula*) *peregrinus* Fries, Elench. Fung. 1: 31. 1828. Collected by Benzon on trunks in Santa Cruz, West Indies. Types not found.

Agaricus (*Flammula*) *ricensis* Fries, Nova Acta Soc. Sci. Upsal. III. 1: 24. 1851. Collected by Oersted on the ground in Costa Rica. It was not figured, but a number of specimens were preserved, none of which could be found either at Upsala or Copenhagen. It differs from most tropical species of the genus in being terrestrial.

Gymnopilus sapineus (Fries) Murrill, Mycologia 4: 254. 1912. So closely related to *G. penetrans* that Fries combined the two in 1821, but later separated them again. Wright's Cuban collections referred to this species at Kew show considerable variation, but none seem to fit the temperate, pine-loving *G. sapineus*, which has also been reported from Guadeloupe, Venezuela, New Zealand, Ceylon, and elsewhere in tropical regions, probably without careful comparison with typical specimens.

10. CREPIDOTUS (Fries) Quél. Champ. Jura Vosg. 106. 1872

This genus contains small, fan-shaped, wood-loving plants with ochraceous or ferruginous spores. The pileus is usually pallid or yellowish, and may be either glabrous or more or less fibrillose or squamulose.

1. CREPIDOTUS CACAOPHYLLUS (Berk. & Curt.) Sacc. Syll. Fung. 5: 883. 1887

A. (*Crepidotus*) *cacaophyllus* Berk. & Curt. Jour. Linn. Soc. 10: 291. 1868.

Described from plants collected by Wright in Cuba. Types not found at Kew. Pileus 1.3 cm. broad, yellowish, squamose; lamellae adnexed, distant, chocolate-brown; stipe very short.

2. CREPIDOTUS MUSAECOLA (Berk. & Curt.) Sacc. Syll. Fung. 5: 883. 1887

A. (*Crepidotus*) *musaecola* Berk. & Curt. Jour. Linn. Soc. 10: 291. 1868.

Described from specimens collected by Wright in Cuba on dead plantain leaves near the ground. Wright's Cuban specimens called *C. alveolus* by Berkeley apparently belong here.

3. CREPIDOTUS PSYCHOTRIAE Pat. Bull. Soc. Myc. Fr. 18: 173. 1902

Described from specimens collected by Duss in Guadeloupe on dead branches of *Psychotria glabrata,* and also found in Martinique. Pileus sessile, convex, orbicular, 0.5–1 cm. broad; surface pale-ochraceous, glabrous, smooth, margin entire; lamellae crowded, broad, brownish; spores ovoid, smooth, $8 \times 5\,\mu$.

4. CREPIDOTUS CITRI Pat. Bull. Soc. Myc. Fr. 18: 172. 1902

Described from specimens collected by Duss at Camp Jacob, Guadeloupe, and later found by him in Martinique. Pileus 2–6 mm. broad, orbicular, thin, soft, glabrous, smooth, brownish-white; lamellae narrow, ochraceous; spores ovoid, smooth, pale-yellow, $7 \times 4\,\mu$.

5. **Crepidotus parvulus** sp. nov.

Pileus thin, soft, fleshy, resupinate, at first orbicular-reniform, becoming conchiform and convex, gregarious, 1–4 mm. broad; surface pure-white, dry, densely floccose-pulverulent, margin even; lamellae radiating from an eccentric point, rounded behind, distant, thin, broad, white to yellowish-ochraceous; spores globose

or subangular, smooth, pale-ochraceous, 4–5 μ; stipe none, point of attachment white, strigose.

Type collected on dead orange branches at Hope Gardens, Jamaica, October 31, 1902, *F. S. Earle 334.* The dried specimens much resemble those of *C. Dussii,* but the pileus is white instead of yellow and the spores only half as large as in that species.

6. CREPIDOTUS DUSSII Pat. Bull. Soc. Myc. Fr. 18: 173. 1902

Pileus 3–5 mm. broad, orbicular, chrome-yellow, glabrous; lamellae broad, distant, yellowish-brown; spores ovoid, smooth, 8–9 × 6 μ. Types examined in the herbarium of Patouillard.

Baines-Jaunes, Guadeloupe, *Duss 411;* Deux-Choux, Martinique, *Duss 1414.*

7. **Crepidotus bicolor** sp. nov.

Pileus thin, rather firm, sessile, dimidiate or flabelliform, usually narrowed behind, the base not strigose, convex or applanate above, gregarious, 5–8 mm. broad; surface dry, glabrous or subglabrous, testaceous to latericious, margin undulate, somewhat sulcate with age or on drying; lamellae radiating from the point of attachment, broad, distant, ventricose, ochraceous-ferruginous; spores globose or subglobose, smooth, ochraceous under a microscope, 6–7 μ.

Type collected on dead wood in British Honduras in 1906, *Morton E. Peck.* Very similar in form to specimens of *Crepidotus croceosanguineus* Mont. collected in Chile by Gay (type) and in Ecuador by Lagerheim, but in that species the colors are reversed, the surface being yellow and the lamellae dark-red.

8. CREPIDOTUS PYRRHUS (Berk. & Curt.) Sacc. Syll. Fung. 5: 879. 1887

A. (*Crepidotus*) *pyrrhus* Berk. & Curt. Jour. Linn. Soc. 10: 291. 1868.

Described from Wright's collections on dead wood in Cuba. His no. 38 is the type, and this is represented at Kew by two sporophores with globose or subglobose, echinulate, ochraceous-fulvous spores 4–5.5 μ. Lower down on the same sheet are three sporophores of no. 38*a,* which with no. 59 represent Berkeley's var. *leiospora,* having, according to him, smooth spores. Speci-

mens cited below from Guadeloupe and Jamaica agree with the type in spore characters, but the color of the spores is ferruginous-fulvous in fresh material. Patouillard has a specimen reaching 3 cm. or more in breadth.

Cuba, *Wright 38;* Guadeloupe, *Duss 1110;* Cockpit Country, Jamaica, *Murrill & Harris 995.*

9. CREPIDOTUS LACERATUS Pat. Bull. Soc. Myc. Fr. 18: 173. 1902

Described from specimens collected by Duss in Guadeloupe. Types examined. Pileus 1–1.5 cm. broad, deeply lacerate, ochraceous-red, pulverulent; lamellae crowded, concolorous; spores ovoid, verrucose, ochraceous, 5–6 × 4–5 μ. Apparently not sufficiently distinct from *C. pyrrhus.*

10. CREPIDOTUS CUNEIFORMIS Pat. Bull. Soc. Myc. Fr. 18: 173. 1902

Known only from specimens collected by Duss on dead wood in Guadeloupe. Pileus about 1 cm. broad, pale-brown, glabrous, striatulate; lamellae broad, soft, brownish; spores globose, smooth, brown, 6 μ.

11. **Crepidotus subcuneiformis** sp. nov.

Pileus thin, rather firm, fragile on drying, broadly wedge-shaped, approaching orbicular, in outline, plane above, tapering to a rather broad base which is not strigose, gregarious, reaching 1 cm. broad and becoming somewhat longer; surface glabrous or pulverulent, moist, dull-isabelline to avellaneous-isabelline, margin very thin, entire, not striate; lamellae radiating from the sessile base, subcrowded, plane, dull-yellowish to umbrinous; spores ovoid, smooth, melleous under a microscope, uniguttulate, 7–8 × 5 μ.

Type collected on a decaying cocoanut husk in Grenada, West Indies, September, 1905, *W. E. Broadway.* Resembling *C. cuneiformis* in gross characters, but quite different under close observation.

12. **Crepidotus sulcatus** sp. nov.

Pileus reniform, dimidiate or resupinate, thin, soft, fleshy, gregarious, 1–2 cm. broad; surface white, becoming ochraceous when dry, glabrous, strigose at the base, sulcate-striate on the margin;

lamellae radiating from an eccentric or lateral point, crowded or subcrowded, rather broad, dark-ochraceous or pale-cinnamon; spores broadly ellipsoid, smooth, pale-cinnamon, 7–8 ×6–7 μ; stipe none, pileus attached by a tuft of strigose hairs.

Type collected on dead fallen branches in Cooper's ranch at the base of El Yunque, near Baracoa, Cuba, March, 1903, *L. M. Underwood & F. S. Earle 761.*

13. **Crepidotus cinchonensis** sp. nov.

Pileus thin, soft, fleshy, convex to plane above, reniform to orbicular, gregarious, attached by a lateral or eccentric point, or by the vertex, sometimes strigose at the base, appearing resupinate when growing on the under side of a trunk, reaching 2 cm. in diameter; surface dull-watery-white, pulverulent to nearly glabrous, striate, margin very thin, pellucid, darker than the rest of the surface on drying; lamellae radiating from a lateral or eccentric point, crowded, thin, fragile, slightly ventricose, dull-watery-white, becoming subfulvous at maturity; spores ovoid to ellipsoid, smooth, pale-melleous under a microscope, 1–few-guttulate, 8–9 × 4–5 μ.

Collected on dead branches of broad-leaved trees at Cinchona, Jamaica, 5,000 ft. elevation, December 25–January 8, 1908–9, *W. A. & Edna L. Murrill 610 (type), 654.* Also collected during the same period at Morce's Gap, Jamaica, *W. A. & Edna L. Murrill 686.* Similar to *C. Citri* in form and general appearance but very much larger. Closely related to *C. sulcatus,* described from Cuba.

14. **Crepidotus aquosus** sp. nov.

Pileus resupinate, thin, delicate, reniform, expanded at maturity, 1–2.5 cm. broad; surface moist, glabrous or subglabrous, watery-brown, deeply sulcate on the margin; context soft and watery; lamellae subcrowded, rather broad, dark-ochraceous or subfulvous; spores globose, smooth, dark-ochraceous, 6–7 μ.

Type collected on a decayed log on Rose Hill, Jamaica, 4,000 ft. elevation, October 30, 1902, *F. S. Earle 293.*

15. **Crepidotus calolepidoides** sp. nov.

Pileus rather thick, fleshy, strongly convex above, concave below, solitary, narrowly attached behind, 2 × 3 × 1 cm.; surface melleous with an ochraceous tint on the umbo, which is decorated

with minute, fulvous, conic elevations; margin striate, dull-brownish in dried specimens, being very distinct in color from the remainder of the surface; attachment of pileus white, finely pubescent or slightly strigose; lamellae broad, not crowded, slightly arcuate, cremeous to fulvous; spores ovoid, smooth, dull-melleous, 8–10 × 5–6 μ.

Type collected on a small dead branch of a deciduous shrub on the Latimer trail, Cinchona, Jamaica, 5,000 ft. elevation, December 25–January 8, 1908–9, *W. A. & Edna L. Murrill 556.* Resembling *C. calolepis,* but with minute conic elevations instead of tomentose-scaly.

16. **Crepidotus substipitatus** sp. nov.

Pileus soft, fleshy, thin, very fragile when dry, orbicular-reniform, expanded, gregarious, about 1 cm. broad; surface moist, subglabrous, dull-ochraceous, not striate at the margin; lamellae adnexed, subcrowded, rather broad, ventricose, ochraceous to dull-cinnamon; spores ovoid or broadly ellipsoid, opaque, dull-cinnamon, minutely punctate, 5–6 × 4 μ; stipe eccentric, short, curved, cylindric, glabrous, shining, dark-reddish-brown, 4–8 mm. long, 1 mm. thick.

Type collected on dead twigs on the ground at the base of El Yunque, near Baracoa, Cuba, March, 1903, *L. M. Underwood & F. S. Earle 1236.* When growing on the under side of sticks, the stipe curves so that the pileus appears resupinate.

17. **Crepidotus fumosifolius** sp. nov.

Pileus sessile, dimidiate or reniform, thin, firm, fleshy, expanded at maturity, scattered, 2–3 cm. broad; surface glabrous or slightly pruinose, whitish or with ochraceous tints, margin even; lamellae crowded narrow, becoming very dark-fuscous or almost purplish, resembling those of species of *Hypholoma;* spores ellipsoid or ovoid, dark-fuscous, 6–7 × 4 μ.

Type collected on a dead log on Rose Hill, Jamaica, 4,000 ft. elevation, October 30, 1902, *F. S. Earle 292.* An anomalous species with lamellae much darker than is usual for the genus.

DOUBTFUL SPECIES

Crepidotus alveolus (Lasch) Sacc. Syll. Fung. 5: 877. 1887. Described in 1829 from specimens collected on beech trunks in

Germany. Reported from Wright's collections in Cuba, which apparently represent *C. musaecola,* and from Duss' collections in Guadeloupe. In assigning the name *C. alveolus* in 1892 to specimens from St. Vincent, West Indies, Massee remarks that they are larger and more crisped and lobed than in the European form, but that there exists no good specific or even varietal distinction between the two forms.

Crepidotus mollis (Schaeff.) Quél. Champ. Jura Vosg. 106. 1872. Described from northern Europe, and widely distributed, but not seen at Kew from the West Indies. Duss' specimens from Guadeloupe bearing this name were not examined.

11. PHOLIOTA (Fries) Quél. Champ. Jura Vosg. 91. 1872

This genus is distinguished by its fleshy stipe and well-developed veil, which forms a conspicuous and persistent annulus. The lamellae may be adnate or adnexed, and the spores vary in color from ferruginous to fulvous. The genus is abundantly represented in temperate regions, while the number of species reported from the tropics is comparatively small.

1. **Pholiota Broadwayi** sp. nov.

Pileus thin, fleshy, convex to expanded, solitary, reaching 3 cm. broad; surface moist or slightly viscid, entirely glabrous, nearly white to pale-isabelline, slightly darker at the center; margin thin, concolorous, entire; lamellae adnate or adnexed, rather narrow and crowded, slightly ventricose, pale-fulvous; spores ovoid, smooth, not apiculate, pale-yellowish-brown under a microscope, 12×7–$8\,\mu$; stipe cylindric, equal, erect, concolorous, glabrous, smooth, hollow, 4–7 cm. long, 2–3 mm. thick; annulus superior, membranous, rather slight and apt to disappear with age.

Type collected on the ground in Grenada, West Indies, April 9, 1905, *W. E. Broadway.*

2. **Pholiota avellanea** sp. nov.

Pileus nearly plane, solitary, about 3 cm. broad and 3 mm. thick; surface smooth, glabrous, dull, pale-avellaneous, slightly darker at the center, margin thin, slightly decurved; lamellae adnate, avellaneous when looked at perpendicularly, close, rather narrow; spores ellipsoid, smooth, dull, pale-melleous, 9×4–$4.5\,\mu$;

stipe enlarged below, crooked, white at the apex, hygrophanous and longitudinally streaked below, 5 cm. long, 4 mm. thick; annulus ample, white, superior, persistent.

Type collected on the ground at Morce's Gap, Jamaica, 5,000 ft. elevation, December 30, 1908, *W. A. & Edna L. Murrill 749.*

3. **Pholiota bryophila** sp. nov.

Pileus plane or slightly depressed, scattered, 2 cm. broad; surface smooth, dry, glabrous, isabelline, margin regular, appearing rather obtuse because of the broad gills; lamellae yellowish to brown, broad, adnate, ventricose; spores ovoid, smooth, deep-ochraceous, mostly uninucleate, 7–8 × 3.5–4.5 μ; stipe cylindric, equal, often curved, smooth, glabrous, subconcolorous, slender and rather tough, 2 cm. long, 2 mm. thick; annulus white, conspicuous, persistent, attached slightly above the middle of the stipe.

Type collected among mosses on a moist limestone cliff at Orizaba, Mexico, 4,000 ft. elevation, January 10–14, 1910, *W. A. & Edna L. Murrill 806.*

4. **Pholiota cinchonensis** sp. nov.

Pileus thin, becoming plane, scattered, 1.5 cm. broad; surface ochroleucous to ochraceous, dry, granular-tomentose, striate, margin straight, even; lamellae adnate with a decurrent tooth, isabelline, rather narrow; spores broadly ovoid or ellipsoid, almost subglobose at times, obtuse at both ends, smooth, varying in content from granular to uninucleate, honey-yellow under the microscope, ochraceous in mass, 7 × 4–5 μ; stipe paler than the pileus, cylindric, glabrous or nearly so, attached at the base to a white mat of mycelium, 1.5 cm. long, 1 mm. thick; annulus white, nearly central, sometimes ample, the stipe below being smooth, at other times more or less distributed in fibrils along the lower part of the stipe.

Type collected on a dead stick in woods at Cinchona, Jamaica, 5,000 ft. elevation, December 25, 1908, *W. A. & Edna L. Murrill 432.*

5. PHOLIOTA UNICOLOR (Vahl) Gill. Champ. Fr. 1: 436. 1878

Pileus hemispheric or campanulate, regular, scattered, 3 cm. broad; surface smooth, glabrous, dry, polished, ochroleucous, splitting at the margin, which is deflexed, straight, sharp, thin,

concolorous; lamellae sinuate-adnexed with a decurrent tooth, broad, close, soon becoming testaceous or latericeous; spores ovoid, pointed at both ends, 1–2-nucleate, pale-ochraceous, 8.5–11 × 3.5–5 μ; stipe equal, cylindric, fibrous, stuffed, the surface glabrous and lustrous like asbestos, subconcolorous, whitish-tomentose at the base, marked at the apex with long gill-traces, 3–4 cm. long, 2–3.5 mm. thick; annulus superior, conspicuous, white.

Collected on dead wood in the Tepeite Valley, Mexico, 7,000 ft. elevation, December 28, 1909, *W. A. & Edna L. Murrill 464.* Several temperate species of fungi were found in that locality.

6. PHOLIOTA MARTINICENSIS Pat. in Duss, Enum. Champ. Guad. 54. 1903

Described from specimens collected by Duss on a dead trunk in the forest at the base of Mt. Pelée, Martinique. Pileus about 1 cm. broad, very regular, reddish-brown, covered with minute scales; annulus very distinct, persistent, pallid; spores ovoid, smooth, brown, 6 × 4 μ.

7. **Pholiota Musae** (Earle)

Pholiotina Musae Earle, Inform. An. Estaç. Centr. Agron. Cuba 1: 241. 1906.

Pileus thin, watery, convex to expanded or depressed, cespitose, 1–4 cm. broad; surface glabrous, hygrophanous, dark-tan, paler when dry, margin at length striate; lamellae adnexed, subcrowded, broad, ventricose, subconcolorous to darker; spores ellipsoid, smooth, pale-fuscous, 15–18 × 9–10 μ; stipe subcylindric, glabrous, shining, pure-white, hollow, 4–6 cm. long, 3–6 mm. thick; veil white, appendiculate or forming a slight, evanescent annulus.

Described from specimens collected on dead banana stalks at Santiago de las Vegas, Cuba, *F. S. Earle 30, 71, 82.*

8. PHOLIOTA CUBENSIS Earle, Inform. An. Estaç. Centr. Agron. Cuba 1: 242. 1906

Pileus fleshy, firm, expanded, scattered or gregarious, 6–12 cm. broad; surface dry, dark-tan, floccose-scaly on the disk, areolate but not striate on the margin; context yellowish, mild but somewhat unpleasant; lamellae sinuate with adnate tooth, crowded, broad, dark-cinnamon; spores ovoid, smooth, melleous under a

microscope, usually 1–2-guttulate, 6–7 × 4–5 μ; stipe subcylindric, slightly enlarged at the base, floccose above, glabrous below, pale-yellow, solid, firm, about 5 × 1 cm.; veil thick, yellowish, leaving an ample, persistent annulus fixed 2 cm. from the apex of the stipe.

Described from specimens collected on the ground under a building at Santiago de las Vegas, Cuba, *A. Meckleff* (*Earle 159*). Also collected later in a nearby field, *Earle 317*.

9. **Pholiota Brittoniae** sp. nov.

Pileus large, fleshy, convex to expanded, becoming depressed at the center, cespitose, reaching 10 cm. broad; surface dry, imbricate-fibrillose to subglabrous, fulvous, becoming fuliginous or blackish with age; margin entire, concolorous, strongly inflexed on drying; lamellae sinuate, with a decurrent tooth reaching as far as the annulus, seceding with age, broad, irregular in shape, subdistant, ferruginous, darker with age; spores broadly ellipsoid to subglobose, conspicuously tuberculate, ferruginous, opaque, 7–9 μ; stipe enlarged below, concolorous, blackening with age, longitudinally furrowed, hollow, reaching 10 cm. long and 1–3 cm. thick; annulus ample, membranous, ferruginous, persistent, fixed near the apex of the stipe; cystidia none.

Type collected about the roots of living *Eucalyptus* trees at Cinchona, Jamaica, 5,000 ft. elevation, October, 1908, *Elizabeth G. Britton 1122*. Also collected in the same locality at the base of a dead standing trunk, December 25, 1908, *W. A. & Edna L. Murrill 447*. Closely related to *Gymnopilus*, but having an ample, membranous, persistent annulus. Its nearest relative is probably *Pholiota ventricosa* Earle, described from California, which has smaller and more elongate spores.

12. HYPODENDRUM Paulet, Icon. 75. 1793

This genus is distinguished from *Pholiota* by its densely scaly stipe. The pileus may be scaly or smooth.

Hypodendrum scobifer (Berk. & Curt.)

A. (*Pholiota*) *scobifer* Berk. & Curt. Jour. Linn. Soc. 10: 289. 1868.

Described from young specimens collected by Wright about the roots of trees in Cuba. About 5 cm. high, pileus 1.2 cm. broad,

both it and the stipe conspicuously decorated with slender, conic, erect scales; spores not examined. Specimens so named in the herbarium of Patouillard, sent from Guadeloupe by Duss, are small, fulvous, very scrobiculate with imbricate scales, and have muricate, flavous spores 8–10 × 4–5 μ. It is possible that these are young stages of a species of *Gymnopilus*.

Additional Doubtful Species

These were unintentionally omitted in the last article of this series, when the group had to be divided for lack of space.

Agaricus (*Galera*) *martianus* Berk. & Curt. Jour. Linn. Soc. 10: 291. 1868. Described from Wright's collections on dead wood in Cuba and also reported from Guadeloupe. Types not seen. The description calls for free lamellae, which would take the species out of this genus.

Agaricus (*Galera*) *macromastes* Fries, Nova Acta Soc. Sci. Upsal. III. 1: 226. 1851. Described from plants collected by Krebs in the island of St. Thomas. Types doubtless destroyed. The species may belong to *Mycena*.

Agaricus (*Galera*) *flocculentus?* Fries, Nova Acta Soc. Sci. Upsal. III. 1: 24. 1851. Collected and figured by Oersted in Costa Rica. There can be little doubt that this is referable to *Conocybe tener*. The species referred to in Epicr. Myc. 209 is *Galera frustulentus*, now placed in *Psathyra*.

New Combinations

For the benefit of those using Saccardo's nomenclature, the following new species in the above article are recombined, as follows:

GYMNOPILUS AREOLATUS = **Flammula areolata**
GYMNOPILUS BRYOPHILUS = **Flammula bryophila**
GYMNOPILUS CHRYSOTRICHOIDES = **Flammula chrysotrichoides**
GYMNOPILUS DEPRESSUS = **Flammula depressa**
GYMNOPILUS EARLEI = **Flammula Earlei**
GYMNOPILUS HISPIDELLUS = **Flammula hispidella**
GYMNOPILUS HYPHOLOMOIDES = **Flammula hypholomoides**
GYMNOPILUS JALAPENSIS = **Flammula jalapensis**
GYMNOPILUS NASHII = **Flammula Nashii**
GYMNOPILUS PALMICOLA = **Flammula palmicola**
GYMNOPILUS PARVULUS = **Flammula parvula**
GYMNOPILUS PHOLIOTOIDES = **Flammula pholiotoides**
GYMNOPILUS SUBPENETRANS = **Flammula subpenetrans**
GYMNOPILUS TENUIS = **Flammula tenuis**

NEW YORK BOTANICAL GARDEN

NEWS AND NOTES

Dr. Neil E. Stevens has been appointed forest pathologist in the Kansas Experiment Station.

The Simmons Bill, a national law regulating the importation of nursery stock, became effective October 1, 1912.

Miss A. E. Jenkins has been appointed scientific assistant in the pathological herbarium of the Bureau of Plant Industry at Washington.

A series of articles on "Edible Toadstools" is being contributed by Mr. McCubbin, of Guelph, to the *Ontario Natural Science Bulletin.*

Several new species of bacteria causing diseases of orchids were recently described by G. L. Pavarino (Atti R. Accad. Lincei V. 20: 233–237. 1911).

A course in city forestry is being offered by the New York State College of Forestry at Syracuse University, including a thorough course in forest pathology.

Mr. J. S. Cooley, assistant in plant pathology at the Virginia Agricultural Experiment Station, has a fellowship at the Missouri Botanical Garden this year.

Dr. Harry B. Humphrey, for three years professor of plant pathology in the State College of Washington, has been advanced to the position of head of the department of botany.

The Japanese chestnut has been found by A. Prunet, at Lindois, to be highly resistant, if not immune, to the black canker or root disease so fatal to the European chestnut.

The classification of the fungi according to their cytological and biological characters has been attempted by P. Vuillemin in one of a series of volumes devoted to fungi.

Insects play only a secondary rôle in the spread of ergot among forage grasses, according to results obtained by E. Gain (Compt. Rend. Soc. Biol. [Paris] 72: 189–191. 1912).

At the school of botany, University of Texas, Dr. I. M. Lewis has been promoted from instructor to adjunct professor and Dr. F. McAllister has been appointed an instructor in botany.

Two important papers on the relationship of the chestnut canker fungus, one by P. J. Anderson and H. W. Anderson and the other by C. L. Shear, appeared in *Phytopathology* for October, 1912.

Professor R. Kent Beattie, formerly head of the department of botany in the State College of Washington, has resigned to accept a position in the Division of Plant Pathology, Bureau of Plant Industry.

A disease of the beech in the Rhine region, which quickly kills trees seventy or eighty years old, is discussed by Dr. P. Magnus (Gesell. Naturf. Freunde Berlin 436–439. 1911), and declared to be due to *Armillaria mucida.*

In an article on some fungous diseases of the prickly pear (Ann. Myc. 10: 113–134. 1912), F. A. Wolf discusses *Sphaerella Opuntiae, Perisporium Wrightii, Hendersonia Opuntiae,* and several other less destructive species.

The very injurious effects of *Armillaria mellea,* which attacks the roots of a great variety of trees, are discussed by W. T. Horne (Mo. Bull. Com. Hort. Cal. 1: 216–225. 1912) and preventive measures of various kinds are suggested.

Professor R. B. Thaxter, of Harvard University, sailed for Trinidad October 11 to continue his researches on the Laboulbe-

niaceae. Professor Lyman, of Dartmouth College, will have charge of Professor Thaxter's work during his absence.

Dr. H. W. Anderson has been appointed Rose professor of botany at Wabash College, and Professor J. S. Caldwell, of the University of Nashville, has accepted the professorship of botany in the Alabama Polytechnic Institute, Auburn, Alabama.

Dr. F. J. Seaver accompanied Dr. N. L. Britton on a visit to the Bermudas in December and obtained a representative collection of the fungi of those islands. Comparatively little had been previously known of this group of plants in the Bermudas.

It is believed by Stockdale, of Barbados, that a number of fungi attacking Para rubber trees, such as *Thyridaria tarda, Hymenochaete noxia, Fomes semitostus,* and *Corticium salmonicolor,* may be introduced through the careless importation of rubber stumps.

The disease known as "peach yellows" is regarded by E. W. Morse and L. W. Fetzer (Science 35: 393. 1912) as a constitutional disease which is inheritable, the well-known symptoms being due to a disturbance of equilibrium among the enzymes of the plant.

An excellent descriptive treatment of the species of *Pholiota* occurring in the region of the Great Lakes, by Edward T. Harper, has recently appeared in the *Transactions of the Wisconsin Academy of Sciences.* Complete notes and very handsome plates of about thirty species are included.

Professor J. C. Arthur and Dr. Frank D. Kern spent a month during the past summer in field work in Colorado in continuation of their investigations of the Uredinales. The time was chiefly spent in the southern and southwestern portions of the state in localities not visited by them on previous trips.

Mr. Guy West Wilson, formerly of the North Carolina Agricultural Experiment Station, was awarded a research scholarship

at the Garden for the month of September to aid him in his researches on parasitic fungi. Mr. Wilson is continuing his work during the year as a graduate student of Columbia University.

C. Maublanc (Agr. Prat. Pays Chauds, 1912) describes a number of fungous diseases of vanilla, among them anthracnose due to *Calospora Vanillae,* brown spotting of the stems caused by *Nectria Vanillae,* rust caused by *Uredo Scabies,* leaf spots caused by *Fusicladium Vanillae, Phyllosticta Vanillae, Amerosporium Vanillae,* and *Ocellaria Vanillae,* and attacks by *Seuratia Coffeicola, S. Vanillae,* and *Cephaleuros Henningsii.*

A disease affecting the twigs of several species of elm, recently described by J. Eriksson (Myc. Centralbl. 1: 35–42. 1912), may be recognized by the small black pustules which dot the surface of the affected shoots. The causative fungus is described as *Exosporium Ulmi.* Careful inspection of nursery stock and the young growing trees and the burning of all dead and infected twigs are recommended as means of control.

A new paint-destroying fungus, described by Professor George Massee (Kew Bull. Misc. 325, 326. 1911) as *Phoma pigmentivora,* was found in England on fresh white paint in hothouses, appearing as pale rose-colored specks which increased in size and became darker in color until most of the paint was attacked and ruined. The presence of 2 per cent. of carbolic acid in the paint was found sufficient to prevent the development of the fungus.

Professor Thomas H. Macbride, professor and head of the department of botany, State University of Iowa, has been granted leave of absence for the year 1912–13, and is spending the time in botanical exploration in the western states. The latter part of the summer was spent in a mycological survey of the region near the snow line of Mt. Ranier with special reference to the Myxomycetes of that locality.

Anderson, P. J., & Anderson, H. W. The chestnut blight fungus and a related saprophyte. Phytopathology 2: 204–210. O 1912.

Discusses the Connellsville fungus for which the name *Endothia virginiana* is proposed and concludes that we have in our territory (1) *Endothia radicalis* (Schw.) Fr., (2) the true blight, *E. parasitica* (Murrill), and (3) *E. virginiana.*

Banker, H. J. Type studies in the *Hydnaceae*—II. The genus *Steccherinum.* Mycologia 4: 309–318. 23 N 1912.

S eccherinum Peckii and *S. basi-badium* spp. nov. are described.

Brooks, C., & De Meritt, M. Apple leaf spot. Phytopathology 2: 181–190. *pl. 17.* O 1912.

A disease caused by *Sphaeropsis malorum.*

Coker, W. C. *Achlya DeBaryana* Humphrey and the prolifera group. Mycologia 4: 319–324. *pl. 78.* 23 N 1912.

Coker, W. C. *Achyla glomerata* sp. nov. Mycologia 4: 325, 326. *pl. 79.* 23 N 1912.

Detmers, F. An ecological study of Buckeye Lake. Proc. Ohio Acad. Sci. 5: 5–138. *pl. 1–12* + *f. 1–31.* My 1912.

The annotated list of plants includes 19 specics of fungi.

Detwiler, S. B. Some benefits of the chestnut blight. Forest Leaves 13: 162–165. O 1912.

Fawcett, H. S. Citrus scab, *Cladosporium citri* Massee. Monthly Bull. State Comm. Hort. California 1: 833–842. *f. 253–260.* O 1912.

Fawcett, H. S. Gum diseases in citrus trees. Monthly Bull. State Comm. Hort. California 1: 147–156. *f. 49–53.* Ap 1912.

Fawcett, H. S. The potato wart disease. Monthly Bull. State Comm. Hort. California 1: 733–736. S 1912.

A fungus disease caused by *Chrysophlyctis endobiotica* Schilb.

Fred, E. B. A study of the quantitative reduction of methylene blue by bacteria found in milk and the use of this stain in determining the keeping quality of milk. Centralb. Bakt. Zweite Abt. 35: 391–428. 30 O 1912.

Contains considerable information of a botanical nature.

Hall, J. G. *Monochaetia Desmazierii.* Mycologia 4: 330, 331. 23 N 1912.

A note on the identity of the fungus causing the large leaf-spot of chestnut.

Heald, F. D., & Lewis, I. M. A blight of the mesquite. Trans. Am. Micros. Soc. 31: 5–9. *pl. 1.* Ja 1912.

Hesler, L. R. The New York apple tree canker. Proc. Indiana Acad. Sci. 1911: 325–339. *f. 1–7.* 1912.

Horne, W. T. Fungous root rot. Monthly Bull. State Comm. Hort. California 1: 216–225. *f. 83–91.* My 1912.

Armillaria mellea the cause of root rot.

Hotson, J. W. Culture studies of fungi producing bulbils and similar propagative bodies. Proc. Am. Acad. Arts and Sci. 48: 227–306. *pl. 1–12.* O 1912.

Includes new species in *Cubonia* (1), *Papulospora* (9), and *Melanospora* (3).

Johnson, A. G. The unattached aecial forms of plant-rusts in North America. Proc. Indiana Acad. Sci. 1911: 375–411. 1912.

Johnson, E. C. The smuts of wheat, oats, barley, and corn. U. S Dept. Agr. Farm. Bull. 507: 3–32. *f. 1–11.* 8 O 1912.

Lewis, I. M. A bacterial canker of plum twigs. Trans. Am. Micros. Soc. 31: 145–149. *pl. 14.* Jl 1912.

A disease caused by *Pseudomonas pruni.*

Lyon, H. L. Iliau, an endemic cane disease. Rept. Exp. Sta. Hawaiian Sugar Planters' Assoc. Bull. 11: 5–28. *pl. 1* + *f. 1–10.* S 1912.

Includes *Melanconium iliau,* the imperfect stage of *Gnomonia iliau* sp. nov., and notes on *M. sacchari.*

Melhus, I. E. Culturing of parasitic fungi on the living host. Phytopathology 2: 197–203. *pl. 20* + *f. 1, 2.* O 1912.

Moore, G. T. Microörganisms of the soil. Science II. 36: 609–616. 8 N 1912.

Murrill, W. A. The *Agaricaceae* of the Pacific Coast—III. Mycologia 4: 294–308. *pl. 77.* 23 N 1912.

New species are described in *Agaricus* (9), *Stropharia* (2), *Drosophila* (5), and *Gomphidius* (1).

Murrill, W. A. Collecting fungi in the Adirondacks. Jour. N. Y. Bot. Gard. 13: 174–178. 23 N 1912.

Murrill, W. A. Illustrations of fungi—XII. Mycologia 4: 289–293. *pl. 74.* 23 N 1912.

The following species of *Russula* are described and illustrated: *R. sericeonitens* Kauffman, *R. Mariae* Peck, *R. emetica* Fries, *R. sulcatipes* Murrill sp. nov., *R. obscura* Romell, *R. uncialis* Peck, *R. foetens* Pers., and *R. rubriochracea* Murrill sp. nov.

Murrill, W. A. New combinations for tropical agarics. Mycologia 4: 331, 332. 23 N 1912.

Murrill, W. A. The *Polyporaceae* of Mexico. Bull. N. Y. Bot. Gard. 8: 137–153. 23 N 1912.

Includes new species in *Coriolopsis* (4), *Coriolus* (6), *Favolus* (1), *Grifola* (1), *Hexagona* (3), *Trametes* (2), *Tyromyces* (1), *Ganoderma* (2), *Daedalea* (1), *Pyropolyporus* (1), *Gleophyllum* (1) and *Lenzites* (1).

Murrill, W. A. Species of *Hydnaceae* appear to be scarce on the Pacific Coast, as elsewhere. Mycologia 4: 330. 23 N 1912.

Short notes on five species collected by the author.

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Owens, C. E. A monograph of the common Indiana species of *Hypoxylon*. Proc. Indiana Acad. Sci. **1911**: 291–308. *f. 1–16.* 1912.

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Sydow, H. Fungi exotici exsiccati. Ann. Myc. 10: 351, 352. 10 Au 1912.

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Taubenhaus, J. J. Root gall diseases of roses, their cause and methods of control. Gard. Chron. Am. 15: 187, 188. *f. 1–3.* O 1912.

Theissen, F. Zur Revision der Gattungen *Microthyrium* und *Seynesia*. Öst. Bot. Zeits. **62**: 275–280. Jl. 1912; 327–329. S 1912; 395, 396. O 1912.

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Vouaux, Abbé. Synopsis des champignons parasites de lichens. Bull. Soc. Myc. France **28**: 177–208. 15 Jl 1912.

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Gnomonia Caryae sp. nov.

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OIDIUM AND ACROSPORIUM

MYCOLOGIA

VOL. V MARCH, 1913 NO. 2

LIBRA
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STUDIES IN NORTH AMERICAN HYPHOMYCETES—II[1]

THE TRIBE OOSPOREAE

DAVID ROSS SUMSTINE

(WITH PLATES 82–84 CONTAINING 28 FIGURES)

Lindau[2] includes in the tribe *Oosporeae* thirteen genera, as follows: *Sporendonema, Malbranchea, Glycophila, Oospora, Monilia, Oidium, Paepalopsis, Halobyssus, Fusidium, Cylindrium, Polyscytalum, Geotrichum, Helicocephalum.*

The plants are small, inconspicuous, and parasitic or saprophytic. The mycelium is generally poorly developed and differs very little from the sporophores. The sporophores are short, lax or rigid. The hyaline or bright-colored spores are produced in chains endogenously or exogenously.

The genus *Sporendonema* was first described by Desmazieres[3] with one species, *S. Casei.* This is generally considered congeneric with the so-called *Oospora Lactis* (Fres.) Sacc., and synonymous with *Oospora crustacea* (Bull.) Sacc. *Chalara mycoderma* Bon. is also cited as a probable synonym of *S. Casei.* Oudeman[4] describes a new species, *S. terrestre,* and redescribes the genus. He transfers the type *S. Casei* to the genus *Torula.* One species has

[1] Studies in North American Hyphomycetes—I. was published in MYCOLOGIA 3: 45–56. March, 1911.

[2] Pflanzenfamilien 1^{1}**: 417. 1900.

[3] Ann. Sci. Nat. I. 11: 246. 1827.

[4] Archives Neerl. 20: 419. 1885.

[MYCOLOGIA for January, 1913 (5: 1–44) was issued January 13, 1913]

MAR 14 1913

been reported from America, *S. myophilum* Sacc.[5] This species was not available for study.

Glycophila, Paepalopsis and *Halobyssus* have not been reported from America. The first one has two species, the other two are monotypic.

The genus *Fusidium*[6] is very indefinite and will require more extended study to determine its limits.

Cylindrium will be discussed under the genus *Polyscytalum*.

The genus *Helicocephalum* is monotypic and does not belong here. It is more closely related to the *Mucoraceae*.[7]

Hill[8] gives the first description of the genus *Monilia*. It is quite interesting and seems worthy of reproduction here:

"Monilia is a genus of Fungi, consisting of a pedicle supporting a number of naked seeds, arranged together in series like the beads of a necklace.

"The Monilia all produce distinct male and female flowers. The male flowers are antherae, placed on short stamina, on the summit of the pedicle, or near the summit, surrounding it in form of fine powder. The female flowers we are able to distinguish nothing of, except the seeds which are arranged together in series, by means of a glutinous matter, and stand sometimes close to one another, sometimes more distinct. In some species these chains of seeds are laid along both sides of the summit of the stalks; in others they are wound round in clusters, and form a kind of tuberous knobs, which terminate it; in others they rise at distances from the very summit of the pedicle, in forms of fingers; and finally, in others they rise more numerous in this form, and near their bases, so as to form a kind of globule, with the extremities of several of the chains of seeds hanging down from them. These clusters of the series of seeds Micheli took for placentae; he also divided this genus into two, under the names of *Botrytis* and *Aspergillus* but the differences, this division is founded upon, are rather specific than generical; we have arranged them all together under one genus."

[5] Ann. Rep. N. Y. State Mus. 41: 80. 1888.
[6] Link, Berl. Mag. 3: 8. 1809.
[7] Thaxter, Bot. Gaz. 16: 201. 1891.
[8] Hist. of Plants 69. 1751.

Under this genus three species are enumerated: *M. capitata, divaricata, ramosa.* It is impossible to tell definitely what species Hill had before him.

The next general reference to this genus is given by Wiggers.[9] Two species are listed: *M. crustacea* = *Mucor crustaceus* Linn. and *M. Aspergillus* = *Mucor Aspergillus* Scop.

Roth[10] accepts the genus, cites Wiggers and enumerates *M. crustacea, cespitosa, aspergillus, nidulans.*

Persoon[11] gives *M. aurea, cespitosa aurea* = *Aspergillus Mich.* 2. He also adds the following species: *M. rosea, glauca, candida, racemosa, simplex.* In a later work[12] the same species are enumerated.

From these references it seems clear that the genus *Monilia* is congeneric with *Aspergillus* and *Penicillium* and should be retained in that group.

The other genera in this tribe will be discussed at more length in the following pages. No attempt is made to give all the probable synonyms. It was deemed advisable to divide some of the genera and make new genera in order to bring together the more closely related species.

Many of the types of this group are not available for study and in a number of cases are no longer in existence. The study of the species of this group must necessarily be based on descriptions.

OIDIUM Link, Berl. Mag. 3: 18. 1809

?*Alysidium* Kunze, Mykol. Hefte 1: 11. 1817. Type, *Alysidium fulvum* Kunze.

ORIGINAL DESCRIPTION: Thallus e floccis caespitosis, septatis, ramosis, decumbentibus; apicibus articulatis; articulis in sporidia secedentibus. Unica species, colore pulchre aureo.

Mycelium well developed, branched, septate, interwoven; sporophores erect or suberect, septate, simple or branched, rigid; spores produced in chains, hyaline or bright-colored.

Type species, *Trichoderma aureum* Pers.

[9] Prim. Fl. Holsat. 111. 1780.
[10] Tent. Fl. Ger. 1: 558. 1788.
[11] Tent. Disp. Meth. Fung. 40. 1797.
[12] Syn. Meth. Fung. 691. 1801.

This genus resembles *Rhinotrichum* in general appearance and in structure, but differs from that genus in the production of spores. In *Rhinotrichum* the spores are produced singly on the upper divisions of the sporophores, in *Oidium* the spores are produced in chains.

KEY TO THE SPECIES

Spores not over 30 μ long.	
Pulvinate, spores 10–20 μ long.	1. *O. aureum.*
Effused, spores 11–30 μ long.	2. *O. simile.*
Effused, spores 12–24 μ long.	3. *O. Murrilliae.*
Spores much larger.	4. *O. megalosporum.*

1. OIDIUM AUREUM (Pers.) Link, *l. c.*

? *Alysidium fulvum* Kunze, *l. c.*
Torula aurea (Link) Corda, Icon. 2: 8. 1837.

Pulvinate or tufts sometimes confluent, floccose, yellow, tawny; mycelium creeping, septate, sending up erect or suberect sporophores; sporophores erect, simple or branched, septate; spores ovoid-ellipsoid, lemon-shaped, colored, 10–12 × 16–20 μ.

On decaying wood.

SPECIMENS EXAMINED: New Jersey, *Ellis,* N. A. F. *1647;* Pennsylvania, *Schweinitz.*

In all probability *Monilia effusa* Peck[13] belongs here.

2. OIDIUM SIMILE Berk. Jour. Bot. 4: 310. 1845

Oospora similis (Berk.) Sacc. Syll. Fung. 4: 23. 1886.
Monilia aureofulva Cooke & Ellis Grevillea 8: 12. 1886.

Effused, forming a dense mass over the substratum, yellow to reddish yellow; mycelium septate, interwoven; sporophores long, simple or branched, septate; spores in chains, globose or subglobose to ovoid, colored, variable in size, 11–20 × 18–30 μ.

On decayed wood.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine.*

This species resembles *Rhinotrichum Curtisii* in general appearance. *Monilia aurantiaca* Peck & Sacc.[14] is in all probability the same as this species.

[13] Ann. Rep. N. Y. State Mus. 42: 128. 1889.
[14] Ann. Rep. N. Y. State Mus. 42: 128. 1889.

3. **Oidium Murrilliae** sp. nov.

Effused, rather thick, powdery, yellow, melleous to ochraceous, at first white; mycelium densely interwoven, branching, septate; sporophores erect or suberect, short, septate; spores in short chains, sometimes branching, colored, irregularly shaped, ellipsoid to lemon-shaped, 12–14 × 20–24 μ.

On decaying wood.

SPECIMENS EXAMINED: Mexico, near Cuernavaca, *W. A.* and *Edna L. Murrill, 446* (type).

The type is in the herbarium of the New York Botanical Garden.

4. OIDIUM MEGALOSPORUM Berk & Curt. Jour. Linn. Soc. 1: 363. 1869

Monilia megalospora (Berk. & Curt.) Sacc. Syll. Fung. 4: 33. 1886. Not *Oidium megalosporum* Speg. Fungi Argentini 4: 122. 1881.

Pulvinate, growing in small tufts, sometimes several tufts confluent, powdery, yellow, pale yellow; mycelium scanty, branched, septate; sporophores very short; spores in short chains, globose or subglobose, granular within, very large, 35–45 μ, occasionally 50–70 μ.

On decayed wood.

SPECIMENS EXAMINED: Delaware, *Cummins;* Florida, *Calkins;* New Jersey, *Curtis;* New York, *Brown, Clinton;* Ohio, *Morgan;* Pennsylvania, *Sumstine;* West Virginia, *Sumstine.*

OOSPORA Wallr. Fl. Crypt. Ger. 2: 182. 1833

ORIGINAL DESCRIPTION: Sporidia subglobosa s. oriformia intricata pellucida, primum concatenata, hypham articulatam simplicem teneram decumbentem mentientia, articulisque inter se facile secedentibus fragilia.

Mycelium scanty, more or less distinct from the sporophores, septate; sporophores thick, erect or decumbent, simple or branched, breaking into chains of spores, friable; spores variously shaped, concatenate, hyaline or bright-colored.

Type species, *Torula fructigena* Pers.

There is some doubt as to the identity of *Oospora candida,* but from the description it is probably a variety or a young stage of *Oospora fructigena* (*Torula fructigena* Pers.). This latter species is given as the second species under the genus, and, in case the former is not considered sufficiently clear to establish the genus, there can be no doubt as to the second species.

KEY TO THE SPECIES

Pinkish to brown.	1. *O. fructigena.*
Gray to ash-colored.	
Pulvinate.	2. *O. cinerea.*
Effused, spores 8–10 × 10–12 μ.	3. *O. Cerasi.*
Effused, spores larger.	4. *O. Linhartiana.*
White or sordid white.	
Spores large, 15–23 × 20–30 μ.	5. *O. fungicola.*
Spores small, 5–8 μ.	6. *O. Ar huri.*
Spores medium, 10–14 μ.	7. *O. Martinii.*

1. OOSPORA FRUCTIGENA (Pers.) Wallr. *l. c.*

Torula fructigena Pers. Obs. Mycol. 1: 26. 1796.
Monilia fructigena Pers. Syn. Fung. 693. 1801.
Oidium fructigenum Link Sp. Pl. 6[1]: 122. 1824.

Pulvinate, sometimes confluent, white at first, then pink to brown; mycelium fasciculate, thin, septate; sporophores erect or suberect, simple or branched, dividing into chains of spores; spores ovoid, obovoid, or lemon-shaped, hyaline or colored, 10–12 × 16–25 μ.

On various fruits, as apple, peach, plum.

SPECIMENS EXAMINED: Canada, *Thaxter;* New York, *Shear;* Ohio; Pennsylvania, *Sumstine;* South Carolina, *Ravenel.*

This fungus is known as the "brown rot" of fruit. It has been investigated by various students and its life history is fairly well known. It might more properly be treated under the perfect stage, *Sclerotinia fructigena* (Pers.) Schroet.

2. **Oospora cinerea** (Bon.)

Monilia cinerea Bon. Handb. Mykol. 76. 1851.

Pulvinate or effused, gray or gray-brown; mycelium branched, septate; sporophores short, erect, branched, breaking into spores;

spores concatenate, ellipsoid, irregular in shape, hyaline or light-colored, 10–12 × 16–18 μ.

On cherries.

SPECIMENS EXAMINED: Pennsylvania, *Everhart, 484.*

This species is closely related to the preceding species. The spores are smaller and the tufts are not so large.

3. **Oospora Cerasi** (Tracy & Earle)

Monilia Cerasi Tracy & Earle, Greene Pl. Baker. 1: 35. 1901.

Effused, covering the entire fruit with a white coating, finally becoming ash-colored; mycelium developed in the fruit, branched; sporophores short, erect, branched, bearing the concatenate spores; spores spherical, lemon-shaped, hyaline or slightly colored, 10–12 μ.

On immature fruit of wild cherry.

SPECIMENS EXAMINED: Colorado, *Tracy* and *Earle, 1083* (part of the original collection).

The effused growth and smaller spores distinguish this species from the two preceding species.

4. **Oospora Linhartiana** (Sacc.)

Monilia Linhartiana Sacc. Syll. Fung. 4: 34. 1886.

Effused, thin, gray-white, spreading along petioles and veins of leaves; mycelium scanty, septate, hyaline; sporophores short, simple or branched, with chains of spores; spores globose, subglobose or ellipsoid, 10–12 × 12–18 μ.

On *Prunus* sp.

SPECIMENS EXAMINED: Canada, *Dearness, 468;* Maine, *Thaxter;* Wisconsin, *Stevens.*

The spore measurements given by Saccardo are somewhat larger than those given above.

5. **Oospora fungicola** (Ellis & Barth.)

Monilia fungicola Ellis & Barth. Erythea 5: 50. 1897.

Effused, thick, forming a felt-like coating, ashen-gray; mycelium hyaline, interwoven, branched, septate; sporophores erect, simple, short; spores in short chains, hyaline, ellipsoid, irregular, 15–23 × 20–30 μ.

On *Lycoperdon giganteum.*

SPECIMENS EXAMINED: Kansas, *Bartholomew* (type).

6. **Oospora Arthuri** nom. nov.

Monilia candida Bon. Handb. Mykol. 76. 1851.

Tufted, confluent, white to yellow-white; mycelium well developed, branched, septate; sporophores erect, simple or branched, bearing the chains of spores; spores globose to ovoid, 5–8 μ.

On mucor culture.

SPECIMENS EXAMINED: Indiana, *Arthur.*

The type specimen grew on decayed wood. The specimen determined as this species agrees well with the original description.

It is regretted that the transfer of this species from one genus to another necessitates a new name. There is already an *Oospora candida.*

7. **Oospora Martinii** (Ellis & Sacc.)

Monilia Martinii Ellis & Sacc. Michelia 2: 376. 1880.

Effused or pulvinate, white with slight rosy tinge; mycelium creeping, scanty, septate; sporophores erect, septate, simple or branched; spores concatenate, globose or subglobose, irregular, colored, 10–14 μ.

On decayed rachis of *Zea Mays.*

SPECIMENS EXAMINED: Pennsylvania, *Martin;* Ohio, Fungi Columb. *1358.*

Monilia sitophila (Mont.) Sacc. is said to be different in color and in the obtuse ends of the spores.

DOUBTFUL SPECIES

Monilia Peckiana Sacc. & Vogl. Syll. Fung. 4: 34. 1886. On *Vaccinium pennsylvanicum.* This is said to be near *Oospora Linhartiana.*

Oosporoidea gen. nov.

Mycelium scarcely differing from the sporophores, interwoven, crustaceous; the sporiferous hyphae breaking up into spores (?) or forming erect or suberect sporophores with hyaline or bright-colored concatenate spores.

Type species, *Oidium Lactis* Fres.

Oosporoidea Lactis (Fres.)

Oidium Lactis Fres. Beitr. Mykol. 23. 1851.

Oospora Lactis (Fres.) Sacc. Syll. Fung. 4: 15. 1886.

Effused, membranaceous, white, forming small patches, sometimes spreading for a considerable distance; mycelium interwoven, septate or simple; sporophores not sharply differentiated from the mycelium, erect or suberect, dividing into spores; spores in chains, irregular in shape and in size, frequently subglobose to ellipsoid, 5–7 × 12–20 μ.

On cheese.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

Toruloidea gen. nov.

Mycelium scanty, simple or branched; sporophores erect or suberect, simple or branched; spores simple, formed in chains by the division of the sporophore, hyaline or bright-colored.

Type species, *Toruloidea effusa* Sumstine.

This genus is closely allied with *Torula*. The principal difference lies in the color of the spores; in *Torula* the spores are dark-colored, in *Toruloidea* hyaline or bright-colored. The genus is separated from *Oospora* by its delicate structure, less developed mycelium, and much smaller sporophores.

KEY TO THE SPECIES

Pale yellow to yellow.	
Effused.	1. *T. effusa.*
Pulvinate.	2. *T. Unangstii.*
White to sordid white.	
Spores globose or nearly so.	3. *T. Nicotianae.*
Spores ellipsoid to cylindrical.	4. *T. Tulipiferae.*
Spores ovoid to obovoid.	5. *T. candidula.*

1. **Toruloidea effusa** sp. nov.

Effused, thick, pale yellow to yellow, pulverulent; mycelium creeping, branched; sporophores short, erect, simple; spores in chains, ellipsoid, hyaline or subhyaline, usually with a short apiculus, 3–4 × 4–6 μ.

On decayed wood. Bemus Point, N. Y.

SPECIMENS EXAMINED: New York, *Sumstine* (type).

The type specimen is in the herbarium of the Carnegie Museum, Pittsburgh.

2. **Toruloidea Unangstii** sp. nov.

Pulvinate, sometimes confluent, but usually in small patches, yellow; mycelium creeping, branched, filiform; sporophores erect, short, bearing long chains of spores; spores yellow, ovoid to ellipsoid, 2–3 × 3–4 μ.

On decayed wood. Transfer, Pa.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine* and *Unangst* (type).

Type specimen is in the herbarium of the Carnegie Museum, Pittsburgh, Pa.

3. **Toruloidea Nicotianae** (Pezz. and Sacc.)

Oospora Nicotianae Pezz. and Sacc. Syll. Fung. 14: 1037. 1899.

Pulvinate or effused, in small patches, white; mycelium filiform, creeping, branched, septate; sporophores short, erect; spores in chains, globose to ellipsoid, 2.5–3 μ.

On tobacco leaves.

SPECIMENS EXAMINED: Ohio.

The original description says the spores are papillate. The specimens examined did not show this character.

4. **Toruloidea Tulipiferae** (Ellis & Mart)

Oospora Tulipiferae Ellis & Mart. Amer. Nat. 16: 1004. 1882.

Thin, effused, white or slightly colored; mycelium subhyaline or light brown, septate; sporophores short, erect; spores hyaline or subhyaline, ellipsoid to cylindrical, concatenate, chains long, branched, 3–4 × 7–9 μ.

On leaves of *Liriodendron*.

SPECIMENS EXAMINED: Pennsylvania, *Martin*.

The specimen examined is likely a part of the original collection, but it was not sufficient for a satisfactory examination. The plants grow on light brown spots on the leaves. A drawing on the label by Dr. Martin shows the chains of spores several times branched. The description here given is more or less compiled from the original.

5. **Toruloidea candidula** (Sacc.)

Oospora candidula Sacc. Michelia 2: 545. 1880.

Pulvinate or effused, white; mycelium creeping, branched; sporophores erect, simple or branched; spores in long chains, hyaline, ovoid or obovoid, 3×5–$6\,\mu$.

On various substances.

SPECIMENS EXAMINED: New Jersey, *Ellis* and *Harkness*.

The specimen is in the New York Botanical Garden and marked *Oospora hyalinula* Sacc.

POLYSCYTALUM Riess. Bot. Zeitung 11: 138. 1853

ORIGINAL DESCRIPTION: Flocci erecti, subrigidi, ramosi; sporae simplices, cylindricae in catenas ramosas, ex floccorum ramorumque apicibus natas seriatae.

Mycelium wanting, or at least not differing from the sporophore; sporophores simple or branching, septate, hyaline or slightly colored; spores borne in chains at the ends of the sporophores, cylindric, obtuse at each end.

Type species, *Polyscytalum fecundissimum* Riess.

The difference between this genus and *Cylindrium* is based on the development of the mycelium. In the latter it is not so well developed. This distinction scarcely constitutes a generic difference and there seems no good reason for maintaining the two genera.

KEY TO THE SPECIES

White to subfuligineous.	1. *P. cylindroides.*
White to sordid white.	2. *P. sericeum.*

1. POLYSCYTALUM CYLINDROIDES Sacc. & Ellis Jour. Mycol. 4: 105. 1888

Tufts small, white to subfuliginous; sporophores a little incrassated from the base, subcylindric, subsimple; spores cylindric, obtusely rounded at each end, spuriously 1-septate, 2.5–3×15–$20\,\mu$.

On fallen oak leaves.

SPECIMENS EXAMINED: New Jersey, *Ellis*, N. A. F. *2455*.

This species is in all probability the same as the following.

2. POLYSCYTALUM SERICEUM Sacc. Michelia 1: 86. 1879

Effused or cespitose, white to sordid white; sporophores short or somewhat elongated, septate; spores concatenate, cylindric, ends obtuse, hyaline, 2.5–3 × 15–18 μ.

On oak leaves.

SPECIMENS EXAMINED: Canada, *Harkness;* New Jersey, Fung. Columb. *1357*; Pennsylvania, *Sumstine*.

GEOTRICHUM Link, Berl. Mag. 3: 17. 1809

ORIGINAL DESCRIPTION: Thallus e floccis caespitosis septatis, ramosis, decumbentibus. Sporadia ovalia, utrinque truncata, inspersa.

Mycelium scanty, floccose, septate, effused or cespitose; sporophores short, simple or branched; spores borne on the ends of the sporophores in chains, short cylindric, hyaline or light-colored.

Type species, *Geotrichum candidum* Link.

KEY TO THE SPECIES

Pulvinate, spores 5–12 μ long.	1. *G. candidum.*
Effused, spores shorter.	2. *G. cuboideum.*

1. GEOTRICHUM CANDIDUM Link, *l. c.*

Small white tufts; mycelium scanty, creeping; sporophores erect, simple or branched, septate, hyaline; spores short cylindric, hyaline, 3–4 × 5–12 μ; the length varies but the thickness is rather constant.

On various substrata.

SPECIMENS EXAMINED: New Jersey, *Ellis*.

2. **Geotrichum cuboideum** (Sacc. & Ellis)

Oospora cuboidea Sacc. & Ellis Michelia 2: 576. 1880.

Effused, forming a thin powdery coat over the substratum, white; mycelium branching, interwoven; sporophores erect, short; spores in chains, cuboid, irregular, 2–3 × 3–4 μ.

On decaying wood.

SPECIMENS EXAMINED: New Jersey, *Ellis*. Probably part of the original collection.

MALBRANCHEA Sacc. Michelia 2: 638. 1880

ORIGINAL DESCRIPTION: Hyphae repentes, intricatae, continuae, hyalinae, v. laete coloratae, hinc inde in ramulos arcuatos abeuntes; ramuli seriatim plurinucleati, dein ex apice conidia cuboidea v. teretiuscula, continua, hyalina v. laete colorata exserentes.

Mycelium creeping, interwoven, branched, septate or continuous, hyaline, or bright-colored; sporophores short, suberect or arcuate, simple; spores in chains, formed endogenously within the extremities of the sporophores.

Type species, *Malbranchea pulchella* Sacc.

1. **Malbranchea pulveracea** (Ellis)

Monilia pulveracea Ellis; Craigin, Bull. Washburn Coll. 1: 69. 1884.

Rhinotrichum pulveraceum Ellis Jour. Mycol. 1: 47. 1885.

Effused, thin, pale yellow; mycelium branched, sparingly septate; sporophores short, suberect, simple or branched, with smooth swollen ends; spores in chains, formed within the swollen ends, globose or ellipsoid, 5–9 μ or 5–7 × 5–12 μ.

On dead wood and bark.

SPECIMENS EXAMINED: Kansas, *Ellis* and *Craigin*.

This species is placed in this genus with some hesitation. In some respects it agrees better with the genus *Glycophila*. The exact formation of spores could not be learned from the herbarium specimen. The original description says that the spores appear at first inside the swollen ends and push out through the investing membrane.

ACROSPORIUM Nees. Sys. Pilze 2: 14. 1817

ORIGINAL DESCRIPTION: Flocci simplices, aggregati, sursum moniliformes, articulis secedentibus inspersi.

Parasitic; mycelium scanty or well developed; sporophores lax, erect, simple, septate; spores produced in chains.

Type species, *Acrosporium monilioides* Nees = *Monilia hyalina* Fr.

This genus contains the conidial stages of the *Erysiphaceae*.

It seems desirable to retain this form-genus, since some of the forms have not yet been definitely associated with known species of the various genera of the *Erysiphaceae*.

Culture work on species of this genus is in progress, and, therefore, a mere enumeration of the species examined is given at present.

1. **Acrosporium hyalina** (Fr.).
   Monilia hyalina Fr. Obs. Mycol. 1: 210. 1815.
   Acrosporium monilioides Nees, *l. c.*
   On various grasses. The conidial stage of *Erysiphe graminis* DC.

2. **Acrosporium obductum** (Ellis & Lang.).
   Oidium obductum Ellis & Lang. Jour. Mycol. 6: 35. 1890.
   On living leaves of young *Quercus*.

3. **Acrosporium Tuckeri** (Berk. & Br.).
   Oidium Tuckeri B. & Br. Grev. 7: 28. 1878.
   On vine leaves. Probably the conidial stage of *Uncinula necator* (Schw.) Burrill.

4. **Acrosporium leucoconium** (Desm.).
   Oidium leucoconium Desm. Ann. de Sci. 13: 102. 1829.
   The conidial stage of *Sphaerotheca pannosa* (Wallr.) Lév. There is a variation in the spelling of the specific name. The following spellings occur, *leuconium* and *leucogonium*.

6. **Acrosporium compactum** (Cooke & Ellis).
   Oidium compactum Cke. & Ell. Grevillea 7: 39. 1878.
   On *Quercus alba*.

7. **Acrosporium Euonymi-japonici** (Salmon).
   Oidium Euonymi-japonici Salmon, Ann. Mycol. 3: 6. 1905.
   No specimen of this species was seen but it is said to be near *A. leucoconium*.

8. **Acrosporium pirinum** (Ellis & Ev.).
   Oidium pirinum Ellis & Ev. Jour. Mycol. 5: 68. 1889.
   On leaves of *Pirus coronaria*.

9. *Acrosporium* sp.
   ?*Microsphaera Platani* Howe, Bull. Torrey Club 5: 4. 1874.

Amphigenous, white, effused, forming a dense stratum on the leaf; mycelium branched, interwoven; sporophores erect, simple, septate; spores smooth, ellipsoid, granular within, 25–27 × 40–50 μ.

On leaves of *Platanus orientalis* L., Pittsburgh, Pa., August, 1912.

It attacks the young leaves usually and causes them to curl up and die. Unless checked it may become a dangerous shade tree disease.

10. **Acrosporium Gossypii** sp. nov.

Hypophyllous, white to sordid white, effused, thin, spreading over the leaf; mycelium branched, interwoven; sporophores erect, simple, dividing into spores; spores barrel-shaped, ellipsoid, truncate at the ends, 16–24 × 40–50 μ.

On *Gossypium* sp. (Cotton). Kingston, Jamaica.

The type was collected by T. D. A. Cockerell and sent to me by Flora W. Patterson, of the Bureau of Plant Industry, Washington, D. C. It was labeled *Oidium erysiphoides*.

Oidium erysiphoides Fr.[15] is a composite species. The name cannot be applied to any particular form of this genus but belongs to all the forms in general.

SPECIES REPORTED

The following species have been reported from North America, but no specimens were examined. They probably belong to the various genera described in this paper.

1. *Oidium albipes* Peck, Ann. Rep. N. Y. State Mus. **30**: 57. 1878.

2. *Oidium Asteris-punicei* Peck, Bull. N. Y. State Mus. **150**: 35. 1911.

3. *Oidium candidum* Schw. Trans. Amer. Philo. Soc. II. **4**: 285. 1832. The type of this species has been lost and the description is too brief for determination.

4. *Monilia Harknessii* Peck, Ann. Rep. N. Y. State Mus. **34**: 49. 1881.

5. *Monilia Avenae* Peck, Bull. Torrey Club **33**: 219. 1906.

[15] Syst. Mycol. 3: 432. 1829.

6. *Monilia viridi-flava* Cooke & Hark. Grevillea 9: 139. 1881.

7. *Monilia diffusa* Ellis & Ev. Jour. Mycol. 1: 44. 1885.

8. *Monilia Peckiana* Sacc. & Vogl. Syll. Fung. 4: 34. 1886. This is said to be the same as *Monilia Linhartiana* Sacc.

9. *Monilia globosa* Schw. Trans. Amer. Phil. Soc. II. 4: 286. 1832. Type is lost.

10. *Oospora cucumeris* Peck, Ann. Rep. N. Y. State Mus. 41: 80. 1888.

11. *Oospora heterospora* Ellis & Ev. Bull. Torrey Club 24: 470. 1897. From the description this seems to belong to the genus *Toruloidea*.

12. *Torula pallida* Berk. & Br. Grev. 3: 14. 1873.

Oospora pallida (Berk. & Br.) Sacc. & Vogl. Syl. Fung. 4: 24. 1886. The type specimen was collected by Ravenel in South Carolina. It evidently is a *Toruloidea*.

Excluded Species

1. *Monilia rubiginosa* Peck, Ann. Rep. N. Y. State Mus. 30: 58. 1878. This has been transferred to the genus *Zygodesmus*.

2. *Monilia pencillata* Ellis & Ev. Jour. Mycol. 4: 54. 1888. This is now considered the same as *Chondromyces aurantiacum* (Berk. & Curt.) Thaxter.

3. *Monilia candida* Peck, Ann. Rep. N. Y. State Mus. 27: 106. 1875. This name is not tenable. The plant is likely the same as *Monilia mycophila* Sacc.

4. *Monilia punctans* Schw. Trans. Amer. Phil. Soc. II. 4: 286. 1832. The type is lost but the species should be referred to *Torula*.

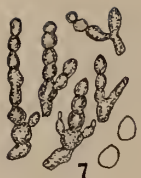
5. *Monilia fusconigra* Schw. Trans. Amer. Phil. Soc. II. 4: 286. 1832. This is a *Torula*.

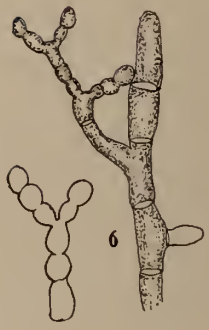
6. *Monilia urediniformis* Ellis & Ev. Proc. Acad. Nat. Sci. Phila. 461. 1893.

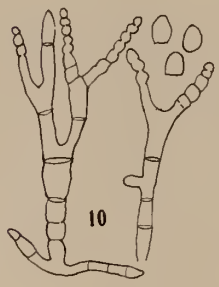
7. *Oidium inquinans* Schw. Trans. Amer. Phil. Soc. II. 4: 286. 1832. A *Torula*.

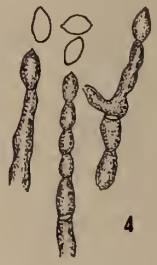
8. *Oidium corticale* Peck, Ann. Rep. N. Y. State Mus. 27: 105. 1875. A *Torula*.

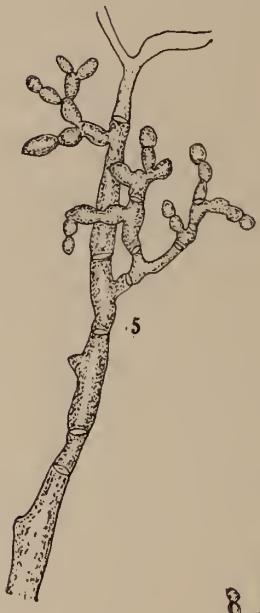
9. *Oidium irregulare* Peck, Ann. Rep. N. Y. State Mus. 33: 29.



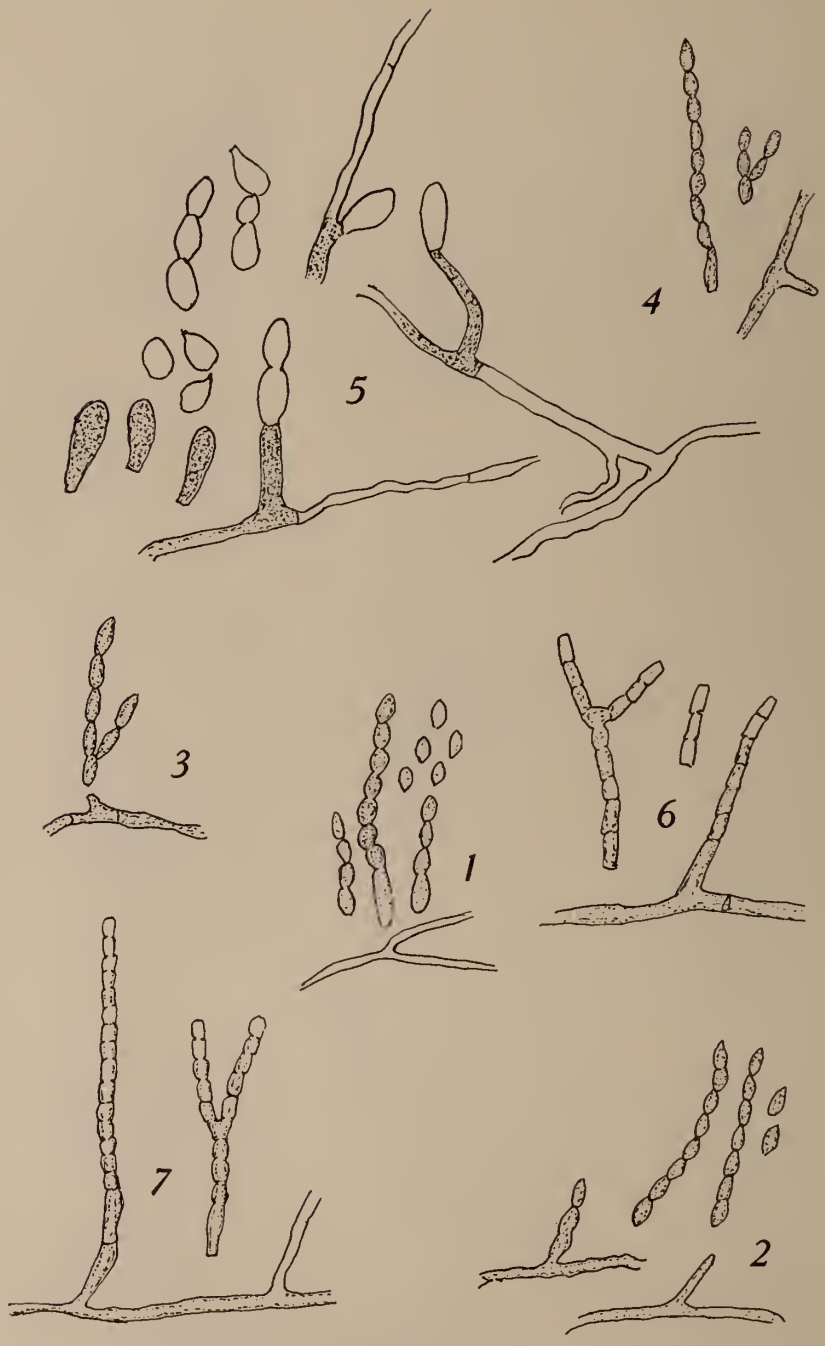








OOSPORA



GEOTRICHUM, MALBRANCHEA AND TORULOIDEA

1880. Saccardo has placed this in the genus *Ovularia* and made it synonymous with *O. isarioides*.

10. *Oospora scabies* Thaxter, Jour. Mycol. 7: 280. 1893. The first report of this species was in 1891.[16] It very evidently does not belong to the genus *Oospora* as defined in this paper. I have not seen authentic specimens, but from the description it would seem better to establish a new genus for this species.

PEABODY HIGH SCHOOL,
PITTSBURGH, PA.

EXPLANATION OF PLATE LXXXII

All the figures on this and the following plates were drawn with the aid of the camera lucida and are highly magnified. The drawings show the mycelium, sporophores and spores.

1. *Oidium aureum* Link.
2. *Oidium simile* Berk. Reproduced from Jour. Bot. 4: 310. *Pl. 12, fig. a, b.*
3–4. *Oidium simile* Berk.
5. *Oidium megalosporum* Berk. & Curt.
6. *Oidium Murrilliae* Sumstine.
7–9. *Acrosporium* sp. 9 shows leaves of *Platanus orientalis.*
10–11. *Acrosporium Gossypii* Sumstine.

EXPLANATION OF PLATE LXXXIII

1. *Oospora fructigena* (Pers.) Wallr.
2–3. *Oospora Linhartiana* (Sacc.) Sumstine.
4. *Oospora cinerea* (Bon.) Sumstine.
5–7. *Oospora Martinii* (Ellis & Sacc.) Sumstine. 7 reproduced from *Fungi Ital. 849.*
8. *Oospora Arthuri* Sumstine
9. *Oospora fungicola* (Ellis & Barth.) Sumstine.
10. *Oospora Cerasi* (Tracy & Earle) Sumstine.

EXPLANATION OF PLATE LXXXIV

1. *Toruloidea effusa* Sumstine.
2. *Toruloidea Unangstii* Sumstine.
3. *Toruloidea Tulipiferae* (Ellis & Mart.) Sumstine.
4. *Toruloidea candidula* (Sacc.) Sumstine.
5. *Malbranchea pulveracea* (Ellis) Sumstine.
6. *Geotrichum candidum* Link.
7. *Geotrichum cuboideum* (Sacc. & Ellis) Sumstine.

[16] Ann. Rep. Conn. Agric. Ex. Station 81. 1891.

TYPE STUDIES IN THE HYDNACEAE—IV.[1] THE GENUS PHELLODON

Howard J. Banker

Phellodon niger (Fries) P. Karst. Rev. Myc. 3[1]: 19. 1881

Hydnum nigrum Fries, Obs. Myc. 1: 134. 1815.

No specimen was found at Upsala that could be regarded with certainty as the type of the species. Specimens under this name in the herbarium presented considerable diversity of characters. A specimen from Karsten collected in 1866 may be considered from its date as having its determination at least approved by Fries. This specimen appears identical in every respect with the American forms which we have referred to the Friesian species[2] and we, therefore, believe that we have rightly interpreted the species.

Phellodon amicus (Quél.)

Hydnum amicum Quél. Grev. 8: 115. 1880.

Hydnum vellereum Peck, Rept. N. Y. State Mus. Nat. Hist. 50: 110. 1897.

The type specimen of *H. amicum* Quél. could not be located, but at Paris authentic specimens from Quélet were found which appeared to be identical in all characters with the American *H. vellereum* Pk.

Phellodon pullus (Schaeff.)

Hydnum pullum Schaeff. Fung. Bavar. 4: 98. *pl. 272.* 1774.

Hydnum zonatum Gmelin, L. Syst. Nat. 2: 1438. 1796.

Hydnum melaleucum Fries, Obs. Myc. 1: 141. 1815.

Hydnum leptopus Pers. Myc. Eur. 2: 170. 1825.

Hydnum graveolens Delast. Fries, Epicrisis 509. 1836–38.

There is, of course, no type specimen of *Hydnum pullum* Schaeff., and our understanding of the species is based chiefly on

[1] Investigation prosecuted with the aid of a grant from the Esther Herrman Research Fund of the New York Academy of Science.

[2] Mem. Torrey Club 12: 166.

Schaeffer's description and figures. These conform in all respects to the American plants which we have placed in this segregation. In Persoon's herbarium at Leyden are a number of specimens labelled in Persoon's handwriting "Hydnum pullum Schaeff." These are typical specimens of our form.

In Fries's herbarium there is no true type specimen of *H. melaleucum* Fr., but the specimens there placed under this name include plants collected as early as 1866 in Upsala by Th. Fries and in Mustiala by P. A. Karsten. These are seemingly identical with our plants. Fries also regarded *H. pullum* Schaeff. as a synonym of his species.[3] The lack of odor noted by Fries is a character on which we think too much stress may be laid. Our plants yield more or less odor.

There are several specimens in Persoon's herbarium labelled "Hydnum leptopus," some of these in Persoon's handwriting. They are nearly all typical plants of this segregation. Fries regarded Persoon's species as a synonym of *H. graveolens* Delast.[4]

There appears to be no type of *H. graveolens* Delast. at Upsala. The only specimens found there referred to Delastre's species were in Starbuck's collection from Sweden and these forms approached more closely to our conception of *Phellodon amicus* (Quél.). At Kew similar forms were commonly referred to *H. graveolens* Delast. Fries's description of *H. graveolens* Delast. also points in some respects to the *amicus* type, particularly his emphasis upon the word *molli* in his description of the character of the pileus. In fact, it might reasonably be claimed that in Fries's conception *H. graveolens* Delast. includes the forms here treated as *Phellodon amicus* (Quél.), in which case the name *graveolens* should prevail for these plants as being the older name. By any other interpretation it is difficult to understand how Fries conceived any difference between *H. graveolens* Delast. and *H. melaleucum* Fr. On the other hand his figure of *H. graveolens* Delast. in his Icones Selectae Hymenomycetes *pl. 6. f. 1* is much more nearly our conception of *P. pullus* (Schaeff.) than of *P. amicus* (Quél.). Moreover, it appears to have been Delastre's idea of the species. In Persoon's herbarium at Leyden is a speci-

[3] Fries, Syst. Myc. 1: 406. 1821.

[4] Fries, Epicr. Myc. 510; Hym. Eur. 616.

men received from Delastre and marked by the latter "graveolens," which is identical in character with the plants that we have regarded as typical of the present segregation. Two other specimens received from Delastre and marked "hydnum fragrans Dtr" are of precisely the same character. In Fries's herbarium at Upsala is a specimen undoubtedly received from Delastre, which is marked "hydnum fragrans. 29 Dstre. 1823. hydnum leptopus var. v. graveolens Pers. Myc. Eur. Sect. 2. p. 171." This is apparently Delastre's hand. In one corner of the label is written in a different hand "graveolens Hym. Eur. p. 606." It seems highly probable that this specimen should be regarded as the type of *H. graveolens* Delast. as published by Fries in Epicr. *loc. cit.* The specimen has the characters of the forms here considered except the upper surface of the pileus is more pubescent, in this respect approaching the character of *P. amicus* (Quél.).

The two species, *P. amicus* (Quél.) and *P. pullus* (Schaeff.), as we have defined them, are closely connected by intermediate forms, and it seems altogether probable that Fries based *H. graveolens* Delast. on some such intermediate form as the one cited above from Delastre and now at Upsala. As a consequence, there has arisen the prevailing confusion concerning the latter species. It is difficult from the evidence at hand to decide in which of the two segregations *H. graveolens* Delast. ought to be included. On the basis of Fries's figure and Delastre's specimens we consider the species as synonymous with *P. pullus* (Schaeff.). Opposed to this, however, is the fact that *H. melaleucum* Fr. is unquestionably a synonym of *P. pullus* (Schaeff.), and Fries distinctly asserts that *H. graveolens* Delast. is distinct from *H. melaleucum* Fr. The only point of difference that he mentions that seems to have any weight is the softer substance attributed to *H. graveolens.* This is the character that points toward *P. amicus* (Quél.).

PHELLODON TOMENTOSUS (L.) Banker, Mem. Torr. Club 12: 171. 1906

Hydnum tomentosum L. Sp. Pl. 2: 1178. 1753.
Hydnum cyathiforme Schaeff. Fung. Bavar. 4: 93. *pl. 139.* 1763.

There is no type of either the Linnaean or the Schaefferian

species in existence. Thanks to the excellent figures of Schaeffer there has never been much confusion as to the forms intended to be included in his species, and they have been more generally known by his name. The Linnaean species has been less clearly understood on account of the very brief diagnosis and the lack of any figure. Nevertheless there appears to be only the one known European species to which his description can apply.

Fries treated these forms as *H. tomentosum* L. in all of his earlier work, but in Hymenomycetes Europaei 606 he rejected the Linnaean name, substituting the name of Schaeffer on the ground that the Linnaean species had the pileus tomentose, while in these forms the disk was only slightly villose or altogether glabrous.[5] While there is some truth in Fries's comment, we believe that he has given it too much weight. It is true that the dark central disk of these forms is often nearly or quite glabrous but not always. Moreover, the whitish or light colored border of the pileus is always quite densely woolly tomentose. In the herbarium at Upsala a specimen was found labelled as follows: "Hydnum tomentosum L. Upsala Sunnerstackog. 1851. E. P. Fries." At first we took this specimen from its dark uniform chestnut or bay color to be a *Hydnellum* rather than a *Phellodon*. It was only by a careful examination of the teeth and especially the spore characters that we became convinced that it was a *Phellodon,* and a representative of the present segregation in which the dark character of the central disk had spread quite to the margin, practically obliterating the usual whitish tomentose border. It may have been such an extreme form that induced Fries to abandon the Linnaean name.

Phellodon carnosus sp. nov.

Hymenophore terrestrial, mesopodous, solitary, light colored, medium size; pileus expanded, plane to subconvex, slightly depressed, subround to irregular, 3–4 cm. wide, 1 mm. thick; surface uneven to nearly even, light grayish brown at center with subpuberulent whitish or cream colored border about 3–4 mm. wide, azonate; margin thin, sterile, incurved in drying; substance

[5] "Ad hanc speciem manifeste non pertinet H. tomentosum Linn., sed pileo tomentoso ad antecedentia (i. e. *H. melaleucum*). H. cyathiforme disco leviter modo villosum l. omnino glabrum." Fries, Hym. Eur. 606.

fleshy, brittle, homogeneous, slightly zonate, pale brown, darker toward base of stem; stem stout, subcylindrical, somewhat abruptly attenuate at base, glabrous or subpuberulent, light to pallid at top, becoming brownish toward base, 2–3 cm. long by 0.5–1 cm. wide, solid, consubstantiate with pileus; teeth short, stout, terete, tapering, acute, shortening toward stem and margin, almost snow white when fresh, becoming whitish to ash-gray in drying, 2 mm. or less long by 0.25–0.35 mm. wide, 5–8 in a sq. mm., somewhat decurrent as papillae; spores hyaline, subglobose, minutely echinulate, 3.5–4 × 4–5 μ wide; hyphae of trama hyaline, smooth, thin-walled, collapsing when dried, recovering in KOH, running parallel and interweaving closely, but separating with some difficulty in KOH, slender, often irregularly contorted and uneven, septate without clamp-connections, segments long, irregular, 4–10 μ wide, branching diffuse, interseptate; odor faint, pleasant; taste mild.

On the ground in coniferous woods; late summer.

The type specimens are in the author's herbarium and were collected along the side of Bleecker pond near Gloversville, N. Y. Specimens of the same species have been collected in Vermont by Burlingham and are in the New York Botanical Garden Herbarium.

This is the most remarkable species in this genus. Its fleshy substance is a radical departure from the usual characters of the species included here. At first it seemed to demand the recognition of a distinct generic type, but the spore characters, the coloration, and even the peculiar odor of the plants pointed so strongly to affinity with the Phellodons that it seemed best to extend the boundaries of the genus so as to include this form at least for the present. Aside from its fleshy substance, it appears to be in every way a Phellodon.

DE PAUW UNIVERSITY,
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NEW SPECIES OF FUNGI[1]

CHAS. H. PECK

Amanita peckiana Kauffm., in litt.

Pileus at first ovate, becoming broadly convex or nearly plane, glabrous at first then fibrillose or somewhat scurfy with minute adnate pinkish or cream-colored squamules, white, not striate, the margin at first incurved and bordered by the thickish union of the universal and partial veil, at length crenate-fringed or lacerate-appendiculate, flesh firm, thickish, white; lamellae free, reaching the stem, moderately broad, much broader in front, subellipsoid, pure-white, flocculose on the edge; stem stout, tapering upward, stuffed or hollow, bulbous, the bulb covered by a thick, firm, loose volva margined with ovate lobes, the flesh often pinkish or salmon-colored, especially toward the base, annulus evanescent, but in the young plant the lamellae are concealed by the very thin inner veil; spores oblong, elongated or subcylindric, obtuse, 12–16 × 5–7 μ, sometimes slightly narrowed toward one end.

Pileus 5–9 cm. broad; stem 5–9 cm. long, 1–2 cm. thick.

Sandy soil under white pine trees, *Pinus strobus* L. New Richmond, Michigan. September. C. H. Kauffman.

An interesting and very distinct species, well marked by the thin, evanescent inner veil and the oblong or subcylindric spores.

Pileus subovatus, obtusus, deinde late convexus vel subplanus, primum glaber, deinde fibrillosus vel minute furfuraceus, albus, non striatus, primum margo incurvus et velis universali imperfectoque incrassatus, demum crenate-fimbriatus vel lacerate-appendiculatus, carne firmo, subcrasso, albo; lamellae liberae, attingentes, sublatae, anteriore latiores, subellipsoideae, candidae, acie flocculosae; stipes validus, deorsum attenuatus, farctus vel fistulosus, bulbosus, bulbo volva crassa, firma, laxa tecto, ovatis lobis marginata, carne saepe infra subincarnate, annulo evanescenti, lamellae juveniles velo tenui tectae; sporae oblongae, elongatae vel subcylindraceae, obtusae, 12–16 × 5–7 μ, aliquando leviter infra attenuate.

[1] Previous articles in this series were published in the *Bulletin of the Torrey Botanical Club*. The form there used is retained.

Collybia subdecumbens

Pilus thin, submembranous, convex or broadly convex, glabrous, grayish-brown or blackish-brown; lamellae thin, subclose, arcuate, adnate, variable in color, whitish-cinereous or tinged with pink; stem straight or nearly so, abruptly bent and decumbent at the base, often compressed and sometimes canaliculate, stuffed or hollow, white, shining; spores ellipsoid, $10.5 \times 4\,\mu$.

Pileus 1–3 cm. broad; stem 4–7 cm. long, 2–5 mm. thick.

Among fallen oak leaves. Stow, Massachusetts. November. S. Davis.

Pileus tenuis, submembranus, convexus vel late convexus, glaber, griseo-brunneus vel nigrescente-brunneus; lamellae tenues, subconfertae, arcuatae, adnatae, in colore variabiles, albidae, cinereae vel subincarnatae; stipes rectus vel subrectus, basi abrupte decumbentus, saepe compressus, aliquando canaliculatus, farctus cavusve, nitidus, albus; sporae ellipsoideae, $10.5 \times 4\,\mu$.

Collybia truncata

Pileus thin, conic or subcampanulate, prominently umbonate, with a truncate umbo, subfibrillose, rarely rimosely areolate, grayish-brown or reddish-brown; lamellae rather broad, subventricose, subdistant, adnexed, whitish or subcinereous, becoming reddish where bruised; stem equal, flexuous, fibrillose, stuffed or hollow, radicating, colored like the pileus; spores subglobose or broadly ellipsoid, $6–8 \times 5–6\,\mu$.

Pileus 2–3 cm. broad; stem 2.5–4 cm. long, 1.5–2.5 mm. thick.

Pine woods. Stow, Massachusetts. November. S. Davis.

Remarkable for its radicating stem, truncate umbo and change of color assumed by the wounds.

Pileus tenuis, conicus vel subcampanulatus, prominente umbonatus, umbone truncato, subfibrillosus, rare rimose areolatus, griseo-brunneus vel rufescente-brunneus; lamellae sublatae, subventricosae, subdistantes, adnexae, albidae subcinereaeve, obtusis rufescentibus; stipes aequalis, flexuosus, fibrillosus, farctus cavusve, radicatus vel basi decumbens, pileo in colore similis; sporae subglobosae vel late ellipsoideae, $6–8 \times 5–6\,\mu$.

Entoloma mirabile

Pileus conic or subcampanulate, with a prominent umbilicate umbo, thin, submembranous, minutely furfuraceous or subsquamulose, blackish-brown; lamellae arcuate, adnate, subdistant,

whitish becoming pink; stem somewhat flexuous, equal, fibrillose, hollow, sometimes compressed and canaliculate, brown, a little paler than the pileus, with white mycelium at the base; spores subglobose, angular, 10–12 μ in diameter, commonly uninucleate.

Pileus 2–3 cm. broad; stem 3–5 cm. long, 2–4 mm. thick.

Swamps under maple trees. Stow, Massachusetts. August. S. Davis.

The species is remarkable for its somber coloring and its prominent umbilicate umbo.

Pileus conicus subcampanulatusve, umbonatus, umbone umbilicato, tenuis, submembranus, minute furfuraceus subsquamulosusve nigrescente brunneus; lamellae arcuatae, adnatae, subdistantes, albidae, incarnatescentes; stipes subflexuosus, aequalis, fibrillosus, fistulosus, aliquando compressus et canaliculatus, brunneus, leviter pileo pallidior, cum mycelio basi albo; sporae subglobosae, angulares, 10–12 μ in diameter, vulgo uninucleatae.

Inocybe minima

Pileus conic-convex or nearly plane, membranous, minutely fibrillose, sometimes umbonate, fragile, inrolled and sometimes split on the margin, tawny-brown; lamellae subdistant, adnate, entire on the margin, pale-tawny-brown becoming darker with age; stem slender, equal, solid, pallid; spores subellipsoid, even, 8–10 $\times$ 4–5 μ, cystidia flask shape, 72–80 $\times$ 20–25 μ.

Pileus 8–12 mm. broad; stem 1–1.5 cm. long, 1–1.5 mm. thick.

Gregarious. Gravelly soil by roadside. South Acton, Massachusetts. August. S. Davis.

Remarkable for its small size. It is referable to the section Lacerae.

Pileus conicus convexus vel subplanus, membranus, minute fibrillosus, subumbonatus, fragilis, margine involutus et aliquando rimosus, fulvo-brunneus; lamellae subdistantes, adnatae, aciei integrae, pallide fulvo-brunneae, in senectute umbrinae; stipes gracilis, aequalis, solidus, pallidus; sporae subellipsoideae, leves, 8–10 $\times$ 4–5 μ, cystidia laguncularia, 72–80 $\times$ 20–25 μ.

Leptonia gracilipes

Pileus thin, membranous, hemispheric-convex or nearly plane, minutely papillate becoming umbilicate, subscabrous, hygrophanous, striatulate when moist, striate when dry, blackish-brown when young, becoming paler with age; lamellae ascending or

arcuate, adnexed, white at first, then pale-flesh-color; stem equal or slightly tapering upward, slender, hollow, glabrous, mouse-gray, becoming blackish in drying, often with white mycelium at the base; spores incarnate, angular, uninucleate, apiculate, 8–10 × 6–7 μ.

Pileus 1–2 cm. broad; stem 2–4 cm. long, 1–1.5 mm. thick.

In a wood road. Stow, Massachusetts. August. S. Davis.

Pileus tenuis, membranus, hemisphaericus convexus vel subplanus, minute papillatus, demum umbilicatus, subscaber, hygrophanus, humidus striatulus, siccus striatus, in juventate nigrescente-brunneus, in senectute pallidor; lamellae ascendentes vel arcuatae, adnexae, primum albae, deinde pallide incarnatae; stipes aequalis vel deorsum leviter attenuatus, gracilis, fistulosus, glaber, murinus, in siccatate nigrescens, saepe basi albido mycelio; sporae incarnatae, angulares, uninucleatae, apiculatae, 8–10 × 6–7 μ.

Leptonia validipes

Pileus thin, membranous, convex, slightly depressed in the center or subumbilicate, fragile, minutely squamulose, dark-gray or grayish-brown; lamellae thin, close, entire on the margin, adnate, white and smooth becoming pink and dusted by the spores; stem stout but fragile, pruinose above, flexuous, hollow, sometimes twisted, often bent at the base, pale-violet-gray above, white below with white mycelium at the base; spores angular, apiculate, uninucleate, 10–12 × 6–8 μ.

Pileus 2–3 cm. broad; stem 3–6 cm. long, 2–3 mm. thick.

Gregarious. On humus in swamps. Stow, Massachusetts. August. S. Davis.

This may possibly prove to be a large stout-stemmed form of *Leptonia gracilipes* Pk. but the description of the collector attributes no striations to the pileus of the fresh plant. This would afford a ready mark of distinction between the two species.

Pileus tenuis, membranus, convexus, in centro leviter depressus vel subumbilicatus, fragilis, minute squamulosus, nigrescente griseus vel griseo-brunneus; lamellae tenues, confertae, aciei integrae, adnatae, albae glabraeque, deinde incarnatae; stipes validus, fragilis, supra pruinosus, flexuosus, fistulose, aliquando contortus, saepe basi recurvus, supra pallide griseo-violaceus, infra albus, basi album mycelium; sporae angulares, apiculatae, uninucleatae, 10–12 × 6–8 μ.

Puccinia striatospora

Spots none; sori epiphyllous or somewhat amphigenous, orbicular, prominent, commonly 1–2 mm. broad, sometimes small, numerous and gregarious, rusty-brown; spores oblong, obtuse, usually slightly constricted at the septum, 35–40 × 20–25 μ, the cells longitudinally striated.

Living leaves of *Heuchera cylindrica* Dougl. Bridge Creek near Chelon Lake, Washington. July. M. E. Jones.

An interesting species, remarkable for and easily distinguished by the striated spores.

Maculae nullae; sori epiphylli vel subamphigeni, orbiculares, prominentes, vulgo 1–2 mm. lati, aliquando parvi, numerosi, gregarii, fulvi; sporae oblongae, obtusae, vulgo ad septum leviter constrictae, 35–40 × 20–25 μ, loculi in longum striati.

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ALBANY, NEW YORK.

THE AMANITAS OF EASTERN NORTH AMERICA

William A. Murrill

(With Plates 85 and 86)

So much has been written on this important group of gill-fungi, both in Europe and America, that it is difficult to review in a brief paper the various opinions that have been held and the numerous discussions that have arisen regarding the identity, variability, distribution, and properties of the species it comprises. My present object is rather to list the chief eastern North American species, with a few of the names under which they have been known, and to add brief notes that students may appreciate. No reference is made here to the poisonous or edible properties of the individual species, as it is the opinion of the writer that the entire group should be strictly avoided by the mycophagist. After reading the following paper it may perhaps be more easily understood why this statement is made. Aside from the great variations in certain species, the accidental loss of a delicate structure like the veil may entirely remove a specimen from a dangerous genus and transfer it to one in which all the known species are harmless.

Venenarius Earle, Bull. N. Y. Bot. Gard. 5: 450. 1909

The type of *Amanita* is *Agaricus campestris,* hence this familiar generic name must be discarded.

Volva free, conspicuous, persistent; stipe not bulbous.
- Volva wide; lamellae yellow; pileus red, orange, or yellow. 1. *V. Caesareus.*
- Volva narrow; lamellae white; pileus white or brown. 2. *V. spretus.*

Volva adnate to the base of the bulbous stipe, limb free, usually persistent; pileus white or variously colored, smooth or with few patches. 3. *V. phalloides.*

Volva ocreate, usually marginate; pileus covered with remnants of the volva.
- Pileus 3–7 cm. broad, white or tinged with yellow or olive. 4. *V. cothurnatus.*

Pileus 8–10 cm. broad, umber-brown, sometimes tinged with yellow. 5. *V. velatipes.*

Volva fragile, adnate to the pileus and stipe as warts, patches, or scales; pileus rarely smooth from the first, often becoming smooth with age.

Flesh at length staining reddish when wounded; pileus usually dull-reddish. 6. *V. rubens.*

Flesh not staining reddish when wounded.

Pileus dark-brown, smooth from the first, margin not striate. 7. *V. Morrisii.*

Pileus orange to yellow, 8–20 cm. broad; stipe usually rough, with concentric, margined scales adnate to the bulbous base. 8. *V. muscarius.*

Pileus chrome-yellow to orange-yellow, 3–8 cm. broad; stipe slender, smooth, with remnants of the fragile, yellowish volva at the base. 9. *V. Frostianus.*

Pileus flavous with a melleous tint to dark-brownish-melleous, 6–10 cm. broad; stipe tomentose to floccose-scaly, reddish below, especially when bruised; volva yellow, fragile. 10. *V. flavorubescens.*

Pileus pale-yellow, 4–5 cm. broad, tuberculate-striate on the margin; stipe smooth, glabrous; volva fragile, subappressed to the bulbous base. 11. *V. russuloides.*

Pileus whitish or grayish tinged with yellow, with peculiar white, webby patches; stipe floccose, mealy above; volva slight, evanescent. 12. *V. crenulatus.*

Pileus white to grayish or murinous, pulverulent, warty, or spiny; stipe bulbous or radicate; odor often strong, resembling chlorine. 13. *V. solitarius.*

1. **Venenarius Caesareus** (Scop.)

Agaricus Caesareus Scop. Fl. Carn. ed. 2, 2: 419. 1772.

Amanita Caesarea Pers. Syn. Fung. 252. 1801.

Amanita pellucida Banning & Peck, Ann. Rep. N. Y. State Mus. 44: 66. 1892. (Type from Maryland.)

Described from Europe, and found in woods from New England to Alabama and west to Ohio.

2. **Venenarius spretus** (Peck)

Agaricus (*Amanita*) *spretus* Peck, Ann. Rep. N. Y. State Mus. 32: 24. 1879.

Described from Sandlake, New York, and found in open or bushy places in the eastern United States from Maine to Alabama.

American specimens determined as *Amanita recutita* Fries doubtless belong in this category.

3. VENENARIUS PHALLOIDES (Fries) Murrill, Mycologia **4**: 240. 1912

Agaricus phalloides Fries, Syst. Myc. **1**: 13. 1821.

Amanita floccocephala Atk. Stud. Am. Fungi 62. 1900. (Type from Ithaca, New York.)

Amanita lignophila Atk. Ann. Myc. **7**: 366. 1909. (Type from Ithaca, New York.)

Amanita bisporigera Atk. Bot. Gaz. **41**: 348. *f. 1–17.* 1906. (Type from Ithaca, New York.)

Described from Europe, and found in America in woods from New Brunswick to Alabama and west to Iowa and California. It was known under several binomials before a part of Vaillant's polynomial was taken up by Fries, but the problem is to find the earliest correct one. Even if *Agaricus bulbosus* Bull. were identical with this species, it is preceded by *Agaricus bulbosus* Schaeff., which is described and figured as having an evanescent volval limb. *A. stramineus* Scop. and *A. citrinus* Schaeff. both seem to apply to *A. Mappa* Fries, which is more or less in doubt. *Amanita verna* Pers., next in line, is based partly on Lamarck's *A. verna,* which is considered the same as *A. virosa* Fries, and partly on *Agaricus bulbosus vernus* Bull., a later name which coincides with our conception of *Amanita verna.* It therefore seems best to adhere for the present to the name assigned by Fries.

The species represents a strong, prevailing type, which assumes various forms and colors in different regions of its wide distribution, and to endeavor to keep them distinct would only confuse students and give them a wrong conception of species.

4. **Venenarius cothurnatus** (Atk.)

Amanita cothurnata Atk. Stud. Am. Fungi 66. *f. 68–70.* 1900.

Described from North Carolina, and found on the ground in woods in the eastern United States from New York to Alabama and west to Pennsylvania and Tennessee. Beardslee considers this species only a white form of *Amanita pantherina.*

VENENARIUS MUSCARIUS (L.) Earle

5. **Venenarius velatipes** (Atk.)

Amanita velatipes Atk. Stud. Am. Fungi 63. *f. 64–67.* 1900.

Known only from specimens collected in beech woods near Ithaca, New York. It resembles *A. pantherina,* but is larger.

6. **Venenarius rubens** (Scop.)

Agaricus rubens Scop. Fl. Carn. ed. 2, **2**: 416. 1772.
Agaricus pustulatus Schaeff. Fung. Bav. **4**: 39. *pl. 91.* 1774.
Agaricus myodes Schaeff. Fung. Bav. **4**: 69. *pl. 261.* 1774.
Agaricus verrucosus Bull. Herb. Fr. *pl. 316.* 1786.
Amanita rubescens Pers. Syn. Fung. 254. 1801.
Amanita aspera Pers. Syn. Fung. 256. 1801.
Agaricus rubescens Fries, Syst. Myc. **1**: 18. 1821. Not *Agaricus rubescens* Schaeff. 1774.
Agaricus asper Fries, Syst. Myc. **1**: 18. 1821.
Agaricus magnificus Fries, Epicr. Myc. 10. 1838.

Described from Europe, and found in woods and groves from Maine to Alabama and west to Ohio. This species is said to have a white variety farther south, which was known to Schweinitz.

7. **Venenarius Morrisii** (Peck)

Amanita Morrisii Peck, Bull. N. Y. State Mus. **139**: 42. 1910.

Described from Massachusetts, and occurring among mosses in swampy places in certain parts of that state.

8. VENENARIUS MUSCARIUS (L.) Earle, Bull. N. Y. Bot. Gard. **5**: 450. 1909

Amanita muscaria Pers. Syn. Fung. 253. 1801.

Described from Europe, and occurring throughout temperate regions in woods and thickets. A pale form found on Long Island is considered by Peck to be closely related to white forms of *A. pantherina,* but to differ in volval characters. I have found small, pale forms under conifers in this vicinity, also a beautiful lemon-yellow form similar in every way to our usual northern orange form except in color. These color variations, together with the tendency of the stipe to be ocreate at times, may be quite confusing. The flesh of this species is said to be bitter, but I have not found it so, either in the fresh or dried state.

9. **Venenarius Frostianus** (Peck)

Agaricus muscarius minor Peck, Ann. Rep. N. Y. State Cab. **23**: 69. 1872.

Agaricus Frostianus Peck, Ann. Rep. N. Y. State Mus. **33**: 44. 1880.

Amanita flavoconia Atk. Jour. Myc. **8**: 110. 1902. (Type from Freeville, New York.)

Described from New York, and found in woods from New Brunswick to Alabama and west to Wisconsin. Among the large number of specimens I have collected, very few are at all marginate or ocreate; in most of them the volva is friable and breaks up rather early. In Peck's first study of the species, he had one of these exceptional plants with a marginate bulb and laid more stress on this character in his description than later collections justified. The species is usually small, but I have found it at Lake Placid with the cap 7 cm. broad and the stem 13 cm. long. It often shows a fondness for decayed wood as a substratum. In collecting one summer at Mountain Lake, Virginia, nearly every specimen seen was growing in the remains of old logs, after the manner of *Russula emetica*.

10. **Venenarius flavorubescens** (Atk.)

Amanita flavorubescens Atk. Jour. Myc. **8**: 111. 1902.

Described from Ithaca, New York, and reported also from Connecticut and Pennsylvania. This species appears commonly from June to September about New York City, under oaks on lawns or in thin woods, and I have had opportunities to study it closely. Its various forms have suggested *V. muscarius, V. rubens,* and *V. russuloides*. The color of the cap varies from flavous with a melleous tint to dark-brownish-melleous, and both the partial and the universal veil are flavous. The remains of the volva have usually mostly disappeared at maturity, but at times they are quite persistent. The base of the stipe is often somewhat enlarged, but is never rounded into a bulb. The characteristic tomentum on the stipe is rarely absent and may usually be relied upon in determining dried specimens.

11. **Venenarius russuloides** (Peck)

Agaricus (*Amanita*) *russuloides* Peck, Bull. Buffalo Soc. Nat. Sci. 1: 41. 1873.

Described from Greenbush, New York, and found in grassy ground in open woods or groves in New York and Massachusetts. According to Beardslee, it is not distinct from *Amanita junquillea* Quél., which, according to Boudier, is the same as *A. vernalis* Gill. and *A. Amici* Gill. The descriptions of *V. russuloides* and *A. junquillea* appear to be identical, except for the "tuberculate margin" of the former. Boudier's figures come nearer to representing our plant than do those of Quélet.

12. **Venenarius crenulatus** (Peck)

Amanita crenulata Peck, Bull. Torrey Club 27: 15. 1900.

Described from eastern Massachusetts, and known to occur in low shaded places in that part of the state. It resembles *V. russuloides* and *V. cothurnatus* in many ways, but the surface has a peculiar flocculent or webby covering similar to that of *V. muscarius,* and the base of the stipe is not ocreate.

13. VENENARIUS SOLITARIUS (Bull.) Murrill, Mycologia 4: 240. 1912

Agaricus solitarius Bull. Herb. Fr. *pl. 48.* 1780.

Agaricus solitarius Fries, Syst. Myc. 1: 17. 1821.

Agaricus strobiliformis Vitt. Fung. Mang. 59. 1835. (Type from Italy.)

Agaricus echinocephalus Vitt. Fung. Mang. 346. 1835. (Type from Italy.)

Agaricus polypyramis B. & C. Ann. Nat. Hist. II. 12: 417. 1853. (Type from South Carolina.)

Agaricus monticulosus B. & C. Ann. Nat. Hist. II. 12: 418. 1853. (Type from South Carolina.)

Agaricus Ravenelii B. & C. Ann. Nat. Hist. III. 4: 284. 1859. (Type from South Carolina.)

Agaricus muscarius major Peck, Ann. Rep. N. Y. State Cab. 23: 69. 1872.

Agaricus (*Amanita*) *onustus* Howe, Bull. Torrey Club 5: 42. 1874. (Type from New York.)

Agaricus (Amanita) chlorinosmus Peck in Austin, Bull. Torrey Club **6**: 278. 1878. (Type from Closter, New York.)

Amanita candida Peck, Bull. Torrey Club **24**: 137. 1897. (Type from Alabama.)

Amanita prairiicola Peck, Bull. Torrey Club **24**: 138. 1897. (Type from Kansas.)

Amanita multisquamosa Peck, Ann. Rep. N. Y. State Mus. **53**: 840. 1900. (Type from New York.)

Amanita radicata Peck, Bull. Torrey Club **27**: 609. 1900. (Type from New Jersey.)

Amanita cinereoconia Atk. Ann. Myc. **7**: 366. 1909. (Type from Chapel Hill, North Carolina.)

Described from Europe, and known in the United States from New York to Alabama and west to California, growing either in open ground or in thin woods. The species is very variable and has been much discussed under a variety of names, some of them older than the ones here listed. A number of other synonyms might be added.

The variations appear in several characters and are conspicuous. The color is usually white, but varies to yellowish, cinereous, gray, or murinous. The surface may be pulverulent, or adorned with flat, gemmate, or spiny scales, which sometimes persist and at other times disappear and leave the surface glabrous. The veil usually tears into shreds, but may persist as an ample annulus. The volva is usually fragile like the veil, but cup-shaped or ocreate forms occur. The base of the stipe may be bulbous, or enlarged and radicate, or slender and radicate. The spores are ellipsoid, but vary much in size, some measurements being as low as 7–10 $\times$ 5–7 μ and others reaching 12–14 $\times$ 7–9 μ. Even the peculiar odor noted in some specimens and described as resembling that of chlorine, chloride of lime, or nitric acid, is definitely stated by responsible collectors to be entirely absent in many cases.

We have represented in this species one of those widely distributed and prevailing types in which variation has run riot, to the confusion of the student and the amazement of the specialist. It would be well if some advanced student or investigator could devote his attention to the morphology of these various forms, studying them as a group, and endeavor to determine the lines

and limits of variation, as well as some of the causes that have operated to produce the forms as we now know them.

DOUBTFUL SPECIES

This list includes species that have not been sufficiently studied by the writer, or species imperfectly known by mycologists generally.

Amanita abrupta Peck, Bull. Torrey Club **24**: 138. 1897. Known only from specimens collected by Underwood and Baker in woods near Auburn, Alabama. It is near *Venenarius solitarius,* but the slender stipe terminated below by a large subglobose bulb distinguishes it from the forms of that species with which I am familiar. It is very desirable that fresh specimens be obtained and color sketches or photographs be made from them for comparison with *V. solitarius* and *V. cothurnatus.*

Amanita elliptosperma Atk. Ann. Myc. **7**: 336. 1909. Described from Chapel Hill, North Carolina. Resembling white forms of *Venenarius phalloides,* but said to have ellipsoid spores. The dried specimens are similar to those of *Amanita verna.*

Amanita elongata Peck, Bull. N. Y. State Mus. **131**: 33. 1909. Described from specimens collected by Sterling in Pennsylvania, July, 1907, on damp grassy ground in the borders of woods. Resembling *Vaginata albocreata,* but having a well-developed annulus. From yellow forms of *Venenarius phalloides,* it differs in its very long, slender stipe and the absence of a free limb to the volva. In color and general appearance, except the long stipe, it greatly resembles *Venenarius Frostianus.* Further field studies are highly desirable.

Amanita flavorubens B. & Mont. Syll. Crypt. 96. 1856. Described from Columbus, Ohio, and reported also from West Virginia. Very near *Venenarius rubens.*

Amanita glabriceps Peck, Bull. N. Y. State Mus. **131**: 18. *pl. U.* 1909. Described from Coopers Plains, New York, and known also from one other locality in the state. Pileus white or yellowish-white, often striate on the margin; stipe long, glabrous or floccose-squamulose, bulbous; volva circumscissile, slightly marginate; spores globose, 8 μ. Dr. Peck states that this species is closely related to *Venenarius phalloides.*

Amanita magnivelaris Peck, Ann. Rep. N. Y. State Mus. **50**: 96. 1897. Described from Port Jefferson, New York, and said by the author to differ from *Amanita verna* in its large, persistent annulus; its elongate, downwardly tapering bulb; and especially in its ellipsoid spores.

Amanita submaculata Peck, Bull. Torrey Club **27**: 609. 1900. Known only from a single specimen, accompanied by a sketch, sent to Dr. Peck from North Carolina by Miss Wilson, who, pronouncing it edible, must have collected more than one sporophore. If it had not been pronounced edible, I should be inclined to classify it as a dark-centered form of *Venenarius phalloides,* in which most of the volva had been carried up on the surface of the cap. The type is sterile, and further field study of the plant is highly desirable.

European Species Reported in America

A number of names are current in America that evidently apply only to European species. Some of these may turn out to be European varieties of species common to both countries.

Agaricus excelsus Fries, Syst. Myc. **1**: 17. 1821

This is not distinct from *Amanita ampla* Pers., according to Boudier.

Venenarius junquilleus (Quél.)

Amanita junquillea Quél. Bull. Soc. Bot. Fr. **23**: 324. *pl. 3. f. 10.* 1876.

It is the opinion of some mycologists that this is not distinct from *Venenarius russuloides.*

Agaricus nitidus Fries, Obs. Myc. **1**: 4. 1815

A mixture of *Amanita citrina alba* Pers. and *Agaricus strobiliformis* Vitt., according to Boudier.

Venenarius pantherinus (DC.)

Agaricus maculatus Schaeff. Fung. Bav. **4**: 39. *pl. 90.* 1774. Not *Agaricus maculatus* Scop. 1772.

Agaricus pantherinus DC. Fl. Fr. **6**: 52. 1815.

Described from France, and found in woods and groves throughout Europe and parts of Asia. I have been unable to find any typical specimens from this country. In the case of *V. phalloides,* we have white and dark forms abundantly represented, and it would seem natural to expect the dark forms of *V. pantherinus* also if the species occurs here. Beardslee has studied *V. cothurnatus* in North Carolina and *V. pantherinus* in Sweden, and he believes the two to be identical. He found the spores of both species to be globose in fresh specimens, changing to ellipsoid after the dried plants were kept for several weeks. *Amanita umbrina* Pers. Syn. Fung. 254. 1801 refers to the usual dark European form of this species. DeCandolle evidently did not use Persoon's name in *Agaricus* because it was preoccupied in that genus.

Venenarius porphyrius (Fries)

Agaricus porphyrius Fries, Syst. Myc. 1: 14. 1821.

Described from Europe, and reported by Beardslee from North Carolina. It is near *V. phalloides,* but the annulus becomes sooty-black with age or on drying.

Venenarius recutitus (Fries)

Agaricus recutitus Fries, Epicr. Myc. 6. 1838.

Specimens of *Venenarius spretus* have been referred to this species in America.

Venenarius spissus (Fries)

Agaricus spissus Fries, Epicr. Myc. 9. 1838.

AGARICUS VIROSUS Fries, Epicr. Myc. 6. 1838

This species has often been confused with white forms of *Venenarius phalloides,* from which it is said to differ in its strong odor and rough stipe.

VAGINATA (Nees) S. F. Gray, Nat. Arr. Brit. Pl. 1: 601. 1821

Amanitopsis Roze, Bull. Soc. Bot. Fr. 23: 50. 1876.

This genus is distinguished from *Venenarius* by the absence of

a veil. Because of the usually prominent sheath or volva in species of both genera, it was formerly customary to regard them as belonging to the same genus, and to speak of them all as "Amanitas."

Volva membranous, free; stipe not bulbous.
  Volva narrow, closely sheathing the stipe.
    Volva elongate, persistent; lamellae white; pileus variously colored. 1. *V. plumbea*
    Volva short, rather friable; lamellae lemon-yellow; pileus orange-red. 2. *V. parcivolvata.*
  Volva wide, not sheathing; pileus dull-white to yellowish, rarely reddish-brown, usually floccose or scaly. 3. *V. agglutina a.*
Volva membranous, adnate to the base of the bulbous stipe, limb free.
  Stipe less than 3 cm. long; pileus pale-brown. 4. *V. pusilla.*
  Stipe much longer; pileus white or yellowish. 5. *V. albocreata.*
Volva fragile, adnate to the pileus and stipe in the form of squamules or patches.
  Pileus mealy or densely floccose; less than 5 cm. broad. 6. *V. farinosa.*
  Pileus decorated with few or many patches; usually more than 5 cm. broad. *V. plumbea strangulata.*

1. **Vaginata plumbea** (Schaeff.)

Agaricus plumbeus Schaeff. Fung. Bav. 4: 37. *pl. 85, 86.* 1774.
Agaricus fulvus Schaeff. Fung. Bav. 4: 41. *pl. 95.* 1774.
Agaricus hyalinus Schaeff. Fung. Bav. 4: 63. *pl. 244.* 1774.
Agaricus badius Schaeff. Fung. Bav. 4: 63. *pl. 245.* 1774.
Agaricus vaginatus Bull. Herb. Fr. *pl. 98.* 1782.
Amanita livida Pers. Syn. Fung. 247. 1801.
Amanita spadicea Pers. Syn. Fung. 248. 1801.
Vaginata livida S. F. Gray, Nat. Arr. Brit. Pl. 1: 601. 1821.
Amanitopsis vaginata P. Karst. Hattsv. 1: 6. 1879.
Vaginata vaginata Murrill, Mycologia 3: 80. 1911.

Described from Bavaria, and occurring very commonly in woods and groves from Greenland to Alabama and west to Oregon and California; also sparingly in the northern Bahamas and the mountains of Jamaica. A number of names have been assigned to the various forms and colors of the plant by European mycologists. That assigned by Schaeffer to the common gray variety appears to be the earliest.

VAGINATA AGGLUTINATA (Berk. & Curt.) O. Kuntze

2. **Vaginata parcivolvata** (Peck)

Amanitopsis parcivolvata Peck, Bull. Torrey Club **27**: 610. 1900.
Amanita muscaria coccinea Beardslee, Jour. Elisha Mitchell Soc. **1**: 8. 1902.

This beautiful species, known to occur in thin woods from New Jersey to North Carolina, has a brilliant orange-red cap, lemon-yellow gills, and a lemon-yellow, pulverulent stem terminated by a short, friable volva. The writer found it under oaks at Blacksburg, Virginia, July, 1910, and compared it carefully with the white, yellow, gray, and blackish forms of *V. plumbea* common in that region. I have not examined Beardslee's specimens, but do not see how they can be distinct.

3. VAGINATA AGGLUTINATA (Berk. & Curt) O. Kuntze, Rev. Gen. **3**: 539. 1893

Agaricus agglutinatus Berk. & Curt. Hook. Jour. Bot. **1**: 97. 1849. (Type from South Carolina.)
Agaricus volvatus Peck, Ann. Rep. N. Y. State Mus. **24**: 59. 1872. (Type from Greenbush, New York.)
Agaricus soleatus Howe, Bull. Torrey Club **5**: 42. 1874. (Type from Yonkers, New York.)
Amanitopsis agglutinata Sacc. Syll. Fung. **5**: 23. 1887.
Amanitopsis volvata Sacc. Syll. Fung. **5**: 23. 1887.

Apparently rare in the warmer parts of temperate Europe and common in the eastern United States, occurring in open woods and wood borders from New England to Alabama and west to Ohio. It varies very much in size, and its surface may be entirely glabrous, or adorned with a few large patches from the volva, or covered with powder much as in *V. farinosa*. The usual color is dull-white or yellowish, but forms with the surface reddish-brown at the center or entirely reddish-brown are found at times. According to Bresadola, *A——— Barlae* Quél. refers to this species, and some think it should be known as *Amanitopsis baccata* (Fries) Sacc.

4. **Vaginata pusilla** (Peck)

Amanitopsis pusilla Peck, Ann. Rep. N. Y. State Mus. **50**: 96. 1898.

Known only from three small sporophores collected by Mrs. Anthony in grassy ground at Gouverneur, New York, in September. The cap is pale-brown when fresh and the gills become brownish. The dried specimens are now not easy to compare, but I cannot definitely connect them with any other known species.

5. **Vaginata albocreata** (Atk.)

Agaricus nivalis Peck, Ann. Rep. N. Y. State Mus. 33: 48. 1883.
Not *Agaricus nivalis* Grev. 1823.
Amanitopsis albocreata Atk. Jour. Myc. 8: 111. 1902.

This species is represented by a number of specimens in the Cornell University Herbarium, and at Albany the peculiar volval differences between it and *V. plumbea alba* are well shown. It is reported from New York to Alabama.

6. VAGINATA FARINOSA (Schw.) Murrill, Mycologia 4: 3. *pl. 56. f. 5.* 1912

Amanita farinosa Schw. Schr. Nat. Ges. Leipzig 1: 79. 1822.
Amanitopsis farinosa Atk. Stud. Am. Fungi 76. 1900.

Described from North Carolina, and found in open deciduous woods from New York to Alabama.

DOUBTFUL AND EUROPEAN SPECIES

Amanitopsis adnata (W. G. Sm.) Sacc. Syll. Fung. 5: 24. 1887. Described from England, and reported from this country by Morgan, Harkness, and others. I have seen no American specimens that could be so referred.

Agaricus baccatus Fries, Epicr. Myc. 12. 1838. Founded on Micheli's plate 80, figure 4, accompanied by a brief description. The warts on the pileus are too evenly distributed, and the volva is too small and circumscissile to suggest our *Vaginata agglutinata*. If an annulus were present, the figure might suggest white forms of *Venenarius pantherinus*.

Agaricus daucipes B. & Mont. Syll. Crypt. 96. 1856. Described from Sullivant's collections at Columbus, Ohio, and placed by Saccardo in *Amanitopsis* although the description expressly

mentions the presence of a veil. Other parts of the description, such as the "radicate stipe" and the "warty pileus" make it pretty clear that the plant is only a form of *Venenarius solitarius*.

Amanitopsis hyperborea P. Karst. Hattsv. 1: 7. 1879. Reported from Greenland by Rostrup (Med. Groenl. 3: 528. 1888), but I have not seen it among American collections.

Agaricus praetorius Fries, Epicr. Myc. 11. 1838. Specimens of *Venenarius Caesareus* from America have been referred to this species.

Amanitopsis pubescens Sacc. Syll. Fung. 5: 25. 1887. *Amanita pubescens* Schw. Schr. Nat. Ges. Leipzig 1: 79. 1822. Described from specimens collected in grassy places in North Carolina. Schweinitz said it was rare, and Morgan, Beardslee, and others say that it has not been collected since his time. The description might suggest *Vaginata farinosa* or *Vaginata agglutinata,* but Schweinitz certainly knew the former and the volva of the latter could not be characterized as "vanishing." Some forms of *Venenarius solitarius* might be thought of, but none of them are quite small enough.

Amanitopsis pulverulenta Peck, Bull. N. Y. State Mus. 116: 17. 1907. Described from plants collected by Peck on shaded roadside banks at Port Jefferson, New York, August, 1906. There are two boxes of specimens at Albany. One contains a single specimen having a long, pulverulent stipe, with bulbous base and no volva, and the pileus covered, except at the center, with a fine powder as in *Lepiota cretacea*. The other box contains several specimens, evidently the types, with short, often radicate, stems and caps that are sometimes gemmate. These latter plants are certainly *Venenarius solitarius,* and there is little doubt that the species belongs in that category.

Amanitopsis strangulata (Fries) P. Karst. Hattsv. 1: 7. 1879. *Agaricus strangulatus* Fries, Epicr. Myc. 6. 1838. Much has been written about this species. Beardslee has recently studied it in Sweden and considers it distinct from *Vaginata plumbea,* being more robust and with an entirely different kind of volva. Boudier is of the same opinion. Fries's description in the *Epicrisis* and Battarra's plate call for an annulus, while Fries's later description and figure refer to the plant as we now know it. If

the plant is distinct, it must have another name, selected from such synonyms as *Agaricus Ceciliae* B. & Br., or *Agaricus inauratus* Secr. In America, it is reported from New England to Alabama and west to Wisconsin. Variations occur all the way from the entire sheath of *V. plumbea* to the extreme form in which the volva is broken into small particles and distributed on the surface of the cap. I will admit that this extremely friable form of the volva is puzzling, but, after all, it is difficult to separate it specifically from the livid form of *V. plumbea.* Lucand has figured a specimen of *V. plumbea* in his group of *A. strangulata.* Did he get the plants mixed, or is this another indication that they are not distinct species?

NEW YORK BOTANICAL GARDEN.

NEWS AND NOTES

Dr. Adeline Ames has been appointed assistant forest pathologist in the Bureau of Plant Industry at Washington.

Mr. E. L. Morris, of the Brooklyn Institute of Arts and Sciences, was elected editor-in-chief of the publications of the Torrey Botanical Club at the annual meeting held January 14.

Dr. Neil E. Stevens, formerly pathologist at the Kansas Agricultural Experiment Station, has been appointed forest pathologist in the Bureau of Plant Industry at Washington.

Professor B. M. Duggar, formerly of the College of Agriculture at Cornell University, has recently been appointed physiologist at the Missouri Botanical Garden and has charge of the graduate laboratory.

Dr. Anton R. Rose, formerly of the department of biological chemistry of Columbia University, has been employed by the New Jersey Agricultural Experiment Station to carry on investigations bearing on the relation of tannin to the chestnut blight.

Hiltner has recently treated chlorosis in fruit-trees and vines (Prakt. Bl. Pflanzbau u. Schutz **10**: 49–51. 1912) by introducing iron and other elements in soluble form through holes bored into the trunks.

A bacterial disease of walnut trees in Tasmania is reported and described by L. Rodway (Agr. Gaz. Tasmania **20**: 85, 86. 1912) as appearing on the nuts and leaves in small black spots and so weakening the tree that death results in a few years.

Under the title "Remarks on Some Species of the Genus *Polyporus*" (Sv. Bot. Tidsk. 6: 635–644. 1912), Romell discusses fourteen Swedish species, two of them, *P. albo-sordescens* and *P. rufopodex*, under new names. Several of the species are figured.

Dr. Charles Horton Peck, our distinguished state botanist, located at Albany, New York, will be eighty years old on March 30. His numerous mycological friends will no doubt extend their hearty congratulations and wish him many happy returns of the day. Dr. Peck has been faithfully serving the state since 1867, almost fifty years.

Professor Ellsworth Bethel has been granted leave of absence for five weeks from his position in the East Denver High School and will spend the time collecting in Costa Rica, Guatemala, and other parts of Central America. He sailed from New Orleans on February 26 for Panama.

Gnomonia Caryae, the perfect stage of *Glocosporium Caryae* Ellis & Dearness, was described by Frederick A. Wolf in the October number of *Annales Mycologici*. This is thought to be the first attempt to connect *Glocosporium Caryae* with its perfect stage and the species is described as new, although close to *Gnomonia setacea macrospora*, which also occurs on fallen leaves of hickory.

At the recent Cleveland meeting, the following officers were elected by the American Phytopathological Society for the current year: F. C. Stewart, president; Haven Metcalf, vice-president; C. L. Shear, secretary-treasurer; W. J. Morse, councilor. The next meeting will be held in Atlanta.

An illustrated paper by H. O. Juel on *Taphrina* and *Exobasidium* (Sv. Bot. Tidsk. 6: 353–372. 1912) deals particularly with species of *Taphrina* occurring on birch in the neighborhood

of Abisko, and with the Scandinavian species of *Exobasidium* growing on the Ericaceae. *Taphrina lapponica*, on *Betula odorata*, is described as new.

C. Wehmer has experimented for some time with dry rot caused by *Merulius lacrymans* (Myc. Centralbl. 1: 138–148, 166–174. 1912) and he has found that the growth of this fungus in cultures may be hindered or stopped by the addition of 0.5 to 5 per cent. tannic acid, and that pine wood may be protected by a 1 to 2 per cent. solution.

The October number of *Annales Mycologici* contains an article on the fungi of the soil by Elizabeth Dale, of Girton College, Cambridge. More than thirty species distributed among twenty genera were obtained from two samples of soil taken from plots on the Royal Agricultural Society's farm at Woburn. The results of similar studies made in this country show a striking similarity to those made in England.

According to the investigations of A. W. Drost, the Panama disease of the Jamaica banana is caused by the fungus *Leptospora Musae* and the disease was present in Surinam before this banana was introduced. The fungus lives in the ground for a long time and has been found to attack different varieties of banana, so that soil once infected with the fungus becomes unfit for banana culture.

Mr. C. R. Orton, for the last year and a half assistant in botany at the Indiana Experiment Station, resigned on January 1 to become plant pathologist and assistant professor of botany in the Pennsylvania State College. Mr. Orton was engaged in the investigation of plant rusts while at the Indiana Station. His place will be temporarily filled by Mr. J. B. Demaree, who recently resigned his position as assistant in botany at the Ohio Experiment Station.

A number of papers on the identity and relationships of the fungus causing the chestnut canker have recently appeared in *Phytopathology* and *Science* under the authorship of P. J. Anderson and H. W. Anderson, Clinton, Farlow, Shear, and others. It is not necessary to give abstracts of these papers here, as they are readily available in the original. A brief foreign paper by Pantanelli, however, which has just appeared (Rend. Accad. Lincei **21**: 869–875. 1912), is important and interesting as bearing on the supposed European origin of the chestnut canker. After a careful comparison of the Italian and American species in question as to their morphological characters, cultural characters, habitat, and parasitism, the author concludes that *Diaporthe parasitica* Murrill [*Endothia parasitica* (Murr.) Anderson] is distinct from *Endothia radicalis* (Schw.) Fries, and, moreover, cannot possibly be of European origin.

Efforts to eradicate or check the chestnut canker are still in progress, and it is hoped that careful scientific experimentation with this disease will aid greatly in the control of less virulent fungous diseases of trees in the future. Mr. Roy R. Pierce, of the Pennsylvania Chestnut Tree Blight Commission, has recently outlined a treatment for ornamental or cultivated chestnut trees that are only slightly affected. This consists in carefully removing the cankers to the depth of six annual rings of wood and painting the wounds with coal-tar containing creosote; then, in order to prevent further infection, spraying the entire tree very thoroughly with strong bordeaux mixture (4: 5: 50). The merit of this treatment is that it is theoretically and scientifically "correct" and that it comes as near to control as anything yet suggested. Speaking *practically*, however, trees covered continuously with copper sulfate and lime do not fit very well into a gorgeous landscape scheme, especially if they are liable to drop a limb or two every few months or to drop out entirely some time while the owner is asleep; and owners of chestnut orchards, who are presumably commercially inclined, are not apt to continue very long a losing fight against a dreaded disease when other equally inviting and far safer fields are open to them.

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ILLUSTRATIONS OF FUNGI—XIV

WILLIAM A. MURRILL

The accompanying plate represents the two most poisonous species of fungi in this region, commonly known as *Amanita phalloides* and *Amanita muscaria*. Certain related species are also represented.

For a discussion of the principal species of this genus occurring in eastern North America, see MYCOLOGIA for March, 1913. The poisonous species of this group are discussed in MYCOLOGIA for November, 1910.

Venenarius phalloides (Fries) Murrill

Amanita phalloides Fries

DEADLY AMANITA. DESTROYING ANGEL

Plate 87. Figure 1. ×1

Pileus convex or campanulate to expanded, 3–15 cm. broad; surface smooth, slightly viscid when moist, glabrous or decorated with scattered patches of the volva, varying in color from pure-white to yellow, yellowish-green, green, gray, brown, or blackish, margin rarely striate; context extremely poisonous, white, not objectionable to the taste but having at times a somewhat disagreeable odor; lamellae white, unchanging, broad, ventricose, rounded at the base and free or adnexed; spores globose, smooth, hyaline, 7–10 μ; stipe subequal, bulbous, long, smooth or floccose-scaly, usually white, stuffed or hollow, 6–15 cm. long, 0.5–1.5 cm. thick; annulus superior, membranous, thin, ample, persistent or at times becoming torn away, usually white; volva white, adnate

MAY 10 1913

[MYCOLOGIA for March, 1913 (5: 45–92), was issued March 10, 1913]

to the base of the large, rounded bulb, the limb usually free, conspicuous, lobed, thick and fleshy, persistent, but at times breaking partly or wholly into irregular patches that are either carried up on the surface of the pileus or remain at the base of the stipe.

This most deadly species of all the fleshy fungi has been often described at length. The reader is referred to MYCOLOGIA for November, 1909, for a discussion of its poisonous properties. The variety of colors assumed by this species—white, yellow, green, gray, brown, blackish—and the fact that the annulus and the limb of the volva may sometimes be lost make it necessary to use great caution in selecting any white-gilled species with bulbous stipe for food, whether an annulus is present or not. All species of *Venenarius* and *Vaginata,* and several species of *Lepiota* must be examined with great care.

Vaginata agglutinata (Berk. & Curt.) O. Kuntze

Amanitopsis volvata (Peck) Sacc.

LARGE-SHEATHED VAGINATA

Plate 87. Figure 2. ×1

Pileus hemispheric to plane, sometimes slightly depressed, very variable in size, 2–8 cm. broad; surface dull-white or yellowish, rarely reddish-brown at the center or entirely reddish-brown, pulverulent, floccose-squamose, or with large volval patches; lamellae free, rounded behind, broad, crowded, white; spores ellipsoid, smooth, hyaline, 10–12 × 6–7 μ; stipe very variable in size, 1–7 cm. long, 3–8 mm. thick, equal or tapering upward, enlarged at the base, whitish, minutely floccose-squamose, stuffed or solid; volva unusually large, firm, membranous, persistent, more or less lobed.

Venenarius muscarius (L.) Earle

Amanita muscaria (L.) Pers.

FLY AMANITA. FLY AGARIC. FLY POISON

Plate 87. Figure 3. ×1

Pileus globose to convex, at length nearly plane, 8–20 cm. broad; surface slightly viscid when fresh, red or orange to yellow, rarely paler, adorned with numerous whitish or yellowish warts, margin slightly striate; context white, yellow under the pellicle, extremely poisonous; lamellae white, rarely pale-yellow-

ish, rather broad; reaching the stipe and forming slight decurrent lines upon it; spores subglobose to ellipsoid, 9–10 × 7–8 μ; stipe subequal, white or pale-yellowish, stuffed or hollow, usually rough with concentric, margined scales adnate to the bulbous base, 8–25 cm. long, 2–3 cm. thick; annulus superior, large, membranous, persistent, white; volva white or yellowish, usually entirely fragile, rarely slightly margining the bulb.

This widely distributed and very dangerous species has several color forms, and it has often been confused with edible species. Its poisonous properties and the use of atropine as an antidote have been considered in previous papers.

Venenarius flavorubescens (Atk.) Murrill

Amanita flavorubescens Atk.

VELVET-STEMMED AMANITA

Plate 87. Figures 4 and 7. ×1

Pileus convex to expanded, scattered or gregarious, sometimes subcespitose, 6–10 cm. broad; surface flavous with a melleous tint to dark-brownish-melleous, usually darker at the center, adorned with yellow or brownish-yellow, floccose patches which may persist or partly disappear with age, margin faintly striate, usually paler; context thin, yellowish; lamellae free to adnexed, not crowded, oblong-elliptic in outline, white, much resembling those of *V. rubens* when dry; spores globose to ellipsoid, smooth, hyaline, 8–10 × 5–8 μ; stipe subequal or tapering upward, usually somewhat enlarged below, but scarcely bulbous, fibrillose or floccose-mealy, at times conspicuously roughened, characteristically tomentose when dry, concolorous or paler above, reddish below, turning slowly to red at the base when bruised, 5–12 cm. long, 5–12 mm. thick; annulus ample, membranous, persistent, flavous; volva flavous or nearly so, friable, the fragments remaining on the surface of the pileus and at the base of the stipe or disappearing according to weather conditions.

The two figures show striking differences in color and form, but the species is a variable one. Figure 4 represents the dark form; figure 7 the normal yellow form with an unusually rough stipe.

Venenarius Frostianus (Peck) Murrill

Amanita Frostiana Peck

FROST'S AMANITA

Plate 87. Figure 5. ×1

Pileus thin, convex to expanded, plane or slightly umbonate, 3–8 cm. broad; surface viscid, adorned with floccose, yellow fragments of the volva, often becoming entirely glabrous, chrome-yellow to orange-yellow, slightly darker in the center, margin smooth or slightly striate; lamellae free, rounded at both ends, subdistant, white or yellowish; spores globose or ovoid, smooth, hyaline, 6–10 μ long; stipe slightly tapering upward from the bulbous base, white or yellowish, smooth, flocculose, stuffed, 6–13 cm. long, 0.4–1.5 cm. thick; annulus membranous, delicate, easily torn away, pale-yellow to chrome-yellow; volva yellowish, usually entirely friable, rarely slightly margining the bulb.

A beautiful species resembling *V. muscarius,* but smaller and more slender and not poisonous.

Venenarius cothurnatus (Atk.) Murrill

Amanita cothurnata Atk.

BOOTED AMANITA

Plate 87. Figure 6. ×1

Pileus globose to convex, at length expanded, 3–7 cm. broad; surface quite viscid when moist, decorated with small, scattered, soft, floccose warts, white or tinged with lemon-yellow, or with the center tawny-olive, even or finely striate on the margin; context white, without odor; lamellae rounded behind, crowded, plane, white; spores globose, smooth, hyaline, 7–9 μ; stipe cylindric, bulbous, flocculose or floccose-scaly, white, hollow or rarely stuffed, 5–12 cm. long, 0.4–1 cm. thick; annulus white, thick, persistent, volva white, adnate to the large, ovoid bulb, circumscissile, breaking uniformly and leaving an abrupt ring at the top of the bulb.

The annulus was very low in the specimen figured and the boot very short. The pileus was also less viscid and somewhat different in color from plants found commonly farther south.

NEW YORK BOTANICAL GARDEN.

THE NATURE AND CLASSIFICATION OF LICHENS—II. THE LICHEN AND ITS ALGAL HOST[1]

Bruce Fink

The writer had no thought, in addressing the questionnaire to botanists three years ago, of attempting to settle thus the classification of lichens. It was thought rather that the views of leading botanists would be valuable, and also that the problems involved could be treated more intelligently after current opinion and the arguments back of it were known. As stated in the first paper of this series, the writer has reserved his own ideas for this paper and another to follow in the series. *Since his views regarding lichens are not those held by most persons who have worked on these plants, the phraseology used, even in the discussions of researches, must be somewhat different from that found in the papers cited. If the facts appear, to those whose writings are considered, to be distorted, careful analysis will probably show that there is no other distortion than that necessarily involved in treatment under a different conception of the nature of the lichen.*

The Presence of Algae in Lichens Established

For centuries lichens and the algae which grow with them were thought to be genetically related. Walroth (137), in the first account of the green cells in lichens, noted their resemblance to certain algae. Elias Fries (60), Kützing (78), Koerber (73, 74), Nägeli (93), Thwaites (129), Thuret (128), Tulasne (136) and Itzigsohn (68) renewed the observations of Wallroth. Some of these and others as Sachs (108), Hicks (67), Nylander (95, 96), Krempelhuber (76), Müller (91) and Arcangeli (2) thought that the algae were the primordia of certain lichens or other stages in their development. Several observers as Bayrhoffer (18), Müller (90, 92), Th. M. Fries (61), Archer (3), Arcangeli (2),

[1] Contributions from the Botanical Laboratory of Miami University—X.

Crombie (41) and Minks (85) committed themselves to the view that the algae arose from the ends of the lichen hyphae.

De Bary (15), and Schwendener (118) more confidently, declared that lichens and certain algae grow together in such intimate relationship as to be long considered parts of the same plant. In spite of the researches of Bonnier (27, 28, 29, 30, 31), Baranetsky (14), Bornet (32, 33), de Bary (15), Famintzin (53, 54), Möller (87, 88), Reess (102), Schwendener (116, 118, 119, 120, 121), Treub (135) and Woronine (144), the European lichenists of that day, as Crombie (40, 41, 42), Th. M. Fries (61), Krempelhuber (76, 77), Minks (85), Müller (92), Koerber (75), Lindsay (83) and Nylander (96, 97) failed to believe that the green cells in lichens are really algae.

With the passing of these men and the coming of a generation of lichenists who agree with other botanists regarding the presence of algae in lichen thalli, it might be supposed that there could not be at present any question regarding the nature and the proper treatment of lichens. However, the only matter thoroughly settled is that the green or the blue-green cells in lichens are algae.

Considerations of Recent Views and Arguments of Botanists

We have been slower to reach an agreement regarding the nature and the proper treatment of lichens than were earlier botanists to find the truth concerning the algae that grow with these plants. True, some botanists have settled the questions involved to their own satisfaction, and others hold a tentative opinion. Advocates of certain ideas regarding lichens have stated, at different times, that their views on the subject were those generally held by the botanical world; but these views have proved, as a result of the statistical study given in the first paper of this series (55), not to be held by a majority of botanists. Moreover, majorities, even of scientific men, are not always right; and we may inquire whether the consensus recently expressed regarding lichens is final. In order to reach a safe conclusion, it has been necessary to review a large portion of the literature of lichenology to ascertain what is valuable for our purpose.

Many botanists were asked, two years ago, to express themselves regarding the classification of lichens, and the results of the correspondence have appeared in MYCOLOGIA (55) for September, 1911. It was supposed that those who replied would deem it necessary, in sustaining their views regarding classification, to state clearly their ideas concerning the more fundamental problem of the nature of lichens. Of the 42 replies quoted, 10 contain no words from which any inference can be drawn concerning the nature of these plants. The other 32 replies touch the matter, for most part, in an obscure manner, often by inference rather than word. This must be taken to mean that those who wrote, with few exceptions, regard the question of the nature of the lichen settled. We may well inquire, then, what these modern botanists said concerning this matter, by word or by reasonably safe inference. Ten of them said nothing. Fourteen stated in more or less certain fashion that lichens are fungi, and 18 appear to believe that lichens are colonies of algae and fungi, or dual organisms. This result, surprising as it is, demonstrates that some form of the dual hypothesis is still much alive, at least in the phraseology used by botanists in writing about lichens, and that the much discussed and vexing problem of the nature of lichens is by no means settled.

In the present condition of affairs, it is difficult for most botanists to write a full page about lichens without contradicting any position taken, unless it be one not far removed from the traditions regarding these plants. As a whole, the replies quoted in MYCOLOGIA are as consistent as anything that has appeared on the subject; yet it would be rash for one who has examined the statements carefully to assume that he is certain that all of these botanists said what they intended. Indeed, some of the replies say that lichens are dual organisms, but should be distributed among fungi. Those who replied thus either believe that lichens are fungi, or that the fungi of the dual organisms should be distributed. But they said neither of these things. One botanist who believes that the lichen is a fungus said positively in his reply that it is a dual organism. A few committed the too common inconsistency of stating that lichens are both dual organisms

and fungi. Of course, these errors of statement result largely from clinging to the traditional phraseology.

TEXT-BOOK TREATMENTS OF LICHENS

Writers of text-books on plant morphology have, with a few notable exceptions, signally failed to be consistent in their treatment of lichens. The 1908 edition of the Strasburger (126) text says on page 348: "Lichens are symbiotic organisms; they consist of filamentous fungi, usually *Ascomycetes,* rarely *Basidiomycetes,* which live in intimate relationship with unicellular or filamentous algae, *Cyanophyceae* or *Chlorophyceae,* and together with these, form a compound thallus or consortium." ("Die Flechten sind symbiotische Organismen, sie bestehen aus Fadenpilzen und zwar aus *Ascomyceten,* nur in ganz vereinzelten Fällen aus *Basidiomyceten,* welche mit einzelligen oder fädigen Algen, *Cyanophyceen* oder *Chlorophyceen,* gemeinsam vegetieren und so einen zusammengesetzen Thallus, ein Konsortium bilden.") This expresses clearly the peculiar idea that the lichen is a fungus and that the consortium is the lichen plus the alga with which it is associated. But the next sentence reads thus: "The lichen-fungi and the lichen-algae should, in a natural system, be classified with the nearest related fungi and algae." (Die Flechtenpilze und Flechtenalgen sind im natürlichen System in die gruppen der nächstverwandten Pilze und Algen einzureihen.) This contradicts the first statement and indicates that the intention was to regard the lichen as a consortium. Fortunately, Lang has corrected the inconsistent statement in the English edition, but the German student still meets this incoherent treatment in his leading text-book.

The Warming-Potter (139) text of 1895 says: "The lichens are fungi . . . which have entered into a peculiar symbiotic relationship with algae." This is coherent and easily understood. But a little below the authors say, "The fungus forms the largest portion of the lichen"; and one wonders how it is, if the lichen is a fungus, as stated in the first quotation, that it does not, as stated in the second, form all of itself. The Curtis (45) text of 1907 has this statement: "The lichen is one of the most remark-

able plants in the vegetable kingdom, since it is the union of two separate plants, a fungus and an alga" (see also 44). This doubtful and confusing statement is left with little explanation, and the author of the book reaches the remarkable conclusion that since "the fungus forms the bulk of the lichen," lichens should be regarded as fungi. The inconsistency of this statement needs only to be pointed out, and yet similar treatment is often found in text-books and elsewhere. The Bergen and Davis text (21) has it thus of lichens: "They are not single plants, but composite organisms made up of algae which are contained in an enveloping mesh of fungal filaments." This plainly makes the lichen a group of algae, though the authors had no intention of saying so remarkable a thing. The Bessey (22) text of 1906 is coherently correct, and the Bergen and Caldwell (20) text of 1911 is quite as coherently incorrect regarding the nature of lichens. These are fair samples of treatment of lichens in texts of general botany.

Writers of texts on plant physiology have held nearer to the traditions concerning lichens and, consequently, have usually made more coherent statements, which have been almost uniformly incorrect.

On the whole, we can not regard the fundamentals of the lichen question settled so long as such confusing, incoherent and erroneous utterances continue to emanate from leading botanists.

RECENT EXPRESSIONS REGARDING THE NATURE OF LICHENS

We are still concerned primarily with the problem of the nature of the lichen and its relation to the algal host. The classification of lichens must be treated last of all, and can not be reached in this paper. Bessey (23, 24, 25, 26) and Clements (35, 37) have expressed themselves to the effect that lichens are fungi and should be distributed to the exclusion of the group Lichenes. Reinke (105, 106) and Schneider (109, 110, 111, 112, 113), at the same time, have been stating at greater length that lichens are distinct from all other plants. When we have finally decided which side of the controversy is in accord with the facts established by research and are able to follow the conclusions reached in a logical manner, we may regard the problem of the nature and the proper treatment of lichens settled.

Reinke, Schneider, and other advocates of consortism, as is well known, regard the relation of the lichen to the alga with which it grows so intimate and mutualistic that the plants growing together must be considered collectively as an individual. It is not deemed essential to the hypothesis that both symbionts should be equally benefited by the association; nor is it regarded necessary that the relation should be beneficial to both symbionts in all respects. It is said by its adherents to be important for the hypothesis that each member should be aided more than injured by the symbiosis, so that the final outcome is advantage to both. Added to this is the intimate union of the two symbionts into what appeared, until de Bary and Schwendener proved otherwise, to be a veritable morphological unit. According to the hypothesis, only one of the symbionts need be wholly dependent upon the other, in order that a new individual may be formed with morphological and physiological characters quite distinct. The other symbiont may be able to live outside the association. The fact established by Frank (58) that certain lower lichens can and do usually exist during a large part of their life outside the relationship with algae is overlooked, and we are given also the contrary statement that the fungus does not and never has existed as such free in nature. It is claimed that the algae found in lichens are more difficult to cultivate than free algae; and this is said to indicate that the algae of these symbiotic associations will in time become as dependent upon the symbiotic relationship as are the fungi now, except perhaps in the lowest lichens. So it is supposed that the relation is becoming closer and closer, and that finally it will be so intimate that neither symbiont will be able to live independently. Then will the individualism be perfect according to the hypothesis. This erroneous hypothesis is refuted by certain considerations to follow in this paper.

The term "consortium" was proposed for the peculiar relation of lichens to algae by Reinke (65, 104, 105), at the suggestion of Grisebach, and was adopted by de Bary (16), who advocated mutualism and individualism, though he seems to have repudiated both later. Recent views expressed by Artari (5, 6), Schneider (109, 110, 111, 112, 114), Peirce (98, 99), Elenkin

(49, 50), Treboux (122), Famintzin (52) and Danilov (46), with the recent enlargement of Reinke (105, 106) upon his original statement, place before us several interesting hypotheses regarding the relation of the lichen to the alga which lives with it. We shall revert to some of these researches toward the close of this paper. Suffice it to state here that Elenkin's hypothesis of endosaprophytism and Danilov's and Peirce's views of parasitism of the lichen upon the alga are quite opposed to the hypotheses of Reinke and Schneider or the more extreme views of Famintzin. In short, the evidence furnished by recent investigation is, as a whole, against all hypotheses of individualism or mutualism. However, granting for the moment, that the relationship is thoroughly mutualistic; that the statement that neither symbiont can live alone, disproved as it is by the cultures of Bonnier (31), Bornet (32), Möller (87, 88) and others, is true; and that the hinted suggestion of Famintzin (52) that the chlorophyll granules of higher plants resemble certain algae and may be such is also proved, some of us would not even then believe the individualism hypothesis to be tenable.

Should such an improbable thing as proving the chlorophyll granules to be veritable algae which could not exist outside the tissue of higher plants come to pass, the writer at least would be disposed to regard these structures, which would not then be genetically related to the plants in which they occur, not parts of the plants, but foreign to them. In short, neither the present relation of the lichen to its symbiotic alga nor any mutualistic relation that may possibly come to pass in the future seems to constitute individualism in any true sense.

It seems remarkable that Danilov (46), Elenkin (49, 50) and Peirce (98, 99, 100) could favor parasitism or saprophytism of lichens upon the algae, and still believe in the dual-nature hypothesis. It will be pointed out below that de Bary did the same in his text-book, and this unreasonable position can be due to nothing else than blindly adhering to the traditions regarding the nature of lichens.

Those who believe that lichens are fungi have not made long arguments for their view. Their efforts have necessarily been

directed mainly toward refutations of mutualism, consortism and individualism; and it is true that lichens resemble other fungi so strongly that there can be no reasonable doubt, once the dual hypothesis is disproved. The best presentation is that of Clements (35). This writer has avoided the inconsistencies so commonly committed by those who treat lichens as fungi, and has given a strong refutation of the consortism hypothesis of Reinke. He also incidentally makes plain, in the paper cited, his views regarding the nature of lichens and their classification. Besides Clements' paper, some of the last 14 quotations in MYCOLOGIA (55) are strong arguments. These are directed mainly toward the less fundamental matter of the distribution of lichens, a consideration barely touched in Clements' paper.

One reads sometimes of the arguments of de Bary and Schwendener for the fungal-nature view, but these men never believed that lichens are fungi. On looking through the 1884 edition of his text-book, one finds that de Bary (17) took the remarkable position that the fungus is parasitic on the alga, but that both are none the less parts of the lichen. His earlier views noted above, in which he recognized consortism, though incorrect, are more tenable. Probably Schwendener's paper of 1873 (121), more than any of his other articles, has caused some botanists to suppose that he regarded lichens as fungi. Indeed, the title would render any other position untenable for him; but, while he maintains that the chlorophyllous cells are algae, wherever he commits himself in the paper, he makes these algae parts of the lichen.

REASONS FOR REGARDING LICHENS AS FUNGI

The main arguments of those who believe that lichens are fungi, so far as they relate to the nature of the lichen rather than to classification, are as follows. The luxuriant growth and the rapid multiplication of algal cells within a lichen are not due to mutualistic relation with the lichen, but rather to some condition of parasitism, perhaps hypernutrition caused by irritation. It is pointed out that the vegetative structure and the fruits of lichens are similar to those of other Ascomycetes. It is said further that phylogenetic and morphological continuity is

apparent enough between *Thelophora* and *Cora*-like lichens, where we have the process of the evolution of new lichen phyla going on before our eyes, and also in the relationship of *Graphis* to *Hysterium, Calicium* to *Mycocalicium, Bilimbia* to *Mycobilimbia, Basidia* to *Mycobacidia, Lecidea* to *Patinella,* etc. It may be added here that the recent papers by Acton (1), Lagerheim (79), Schneider (114), de Seynes (122, 123), Zukal (151) and others add to the evidence through the discovery of many lichens in the making. These researches are considered at length below.

The arguments of those who believe that lichens are fungi seem perfectly tenable, but close analysis is necessary. For the writer at least, it matters not whether the relation of the lichen to the alga is parasitism, saprophytism, or mutualism, even of the type that is believed by some botanists to be the acme of individualism, for it seems reasonable to him to regard the lichen a fungus if the relation is the most mutual possible as well as if it is antagonistic. But the problem arises whether it is consistent to regard the lichen a fungus, since in so doing we are ignoring part of that which was originally considered a portion of the lichen, viz., the symbiotic alga. The zoölogists do not regard zoöchlorellae a part of *Hydra viridis,* fresh water sponges, or other animals in which they occur. Though the symbiotic relation of the lichen to the alga is different from that of the hydra or the sponge to the alga found within it, and though the alga may sometimes form a larger portion of the symbiotic colony than does the lichen, congruity demands excluding the alga from our conception of the lichen.

It has been suggested that the term lichen should be given over to plant physiologists and ecologists, to signify a colony of special interest to them. There are at least two difficulties with this proposition. The first is that most botanists will continue to use the term lichen for purposes of taxonomy and morphology, in spite of any suggestions that might be made, and the second is that relegating the term to workers in certain fields of botanical work would not be the best solution, were it feasible. After studying the literature of lichen physiology and ecology carefully, it does not appear best for physiologists and ecologists to depart from the usual method and consider colonies rather than individ-

uals. Ecological and physiological studies of the lichen and the alga with which it lives are just as interesting and more comprehensible when these plants are considered in their proper relation as independent but intimately associated organisms. Furthermore, this method in plant physiology and ecology would aid in bringing botanists into general accord as to method of treating these plants, and would thereby help do away with the inconsistency and confusion which make it so difficult for botanists to express themselves in a coherent manner regarding lichens. The physiologists and the ecologists have been less inclined than taxonomists to depart from the traditions concerning lichens; but they may well ponder carefully the latest views of leading lichenists (55), who are as much disposed to think that lichens are fungi as are other morphologists and taxonomists. The one argument in recent years for not considering the lichen a fungus pure and simple has been the supposed mutualistic relation of the lichen to the alga, and this has been made to appear untenable by the recent researches of Danilov, Elenkin, Peirce and others cited above. In view of these investigations, it would seem that plant physiologists and ecologists, especially, should abandon the dual hypothesis, which is not tenable in any form or under any condition of mutualism and is wholly unreasonable if it is admitted that the relation of the lichen to the alga is antagonistic. The researches bearing on this problem are considered at length toward the close of this paper.

DIFFICULTIES TO BE MET IN TREATING LICHENS AS FUNGI

Plainly, the only consistent view is that the lichen is a fungus. But having reached this position, there is difficulty enough for mycologists, especially those that study Ascomycetes, to which the lichens very largely belong. Botanists seem, as a rule, to think that the relationships of lichens to other Ascomycetes should be ascertained by lichenists, while students of non-algicolous Ascomycetes, trained as badly in this matter as are the lichenists, continue to avoid the study of algicolous Ascomycetes. This position seems wholly unreasonable. If we are ever to know the relationships of algicolous to non-algicolous Ascomycetes, lines of cleavage in study must cease to be determined by the food habits of

these plants. Forms that appear to be closely related must be studied together, whether all are algicolous, all non-algicolous, or part of them one and part the other. Nor is it necessary that one worker should attempt to study all Ascomycetes, except in a very general way.

Another difficulty is that lichen descriptions have usually been based upon the assumption that the alga forms part of the lichen. Lichenists, even those who believe that lichens are fungi, still for most part continue to give, in their descriptions, details regarding the size and the form of the algae enclosed within lichen thalli. Statements regarding the algae should not be given as a part of descriptions of species, genera, or larger groups of lichens, but should follow or precede the descriptions. The changes needed are greatest in those lichens which grow throughout the algal colonies. The well known *Collema pulposum* (Bernh.) Ach. will serve as an illustration. The thallus has been described hitherto as orbicular or irregular, middle-sized, very gelatinous when wet, frequently showing a rosulate arrangement of the lobes, rather thick especially toward the center, leek-green, olivaceous or blackening, the lobes repand-crenate, etc. This is mainly a description of the algal colony in which the lichen is imbedded. The lichen thallus should be described somewhat as follows: thallus a loose network of hyaline, septate, branching hyphae, which are 2.5 to 4 mic. in diameter, with cells 15 to 30 mic. long; simple rhizoids hyaline to light brown, with cells 4 to 5.5 mic. in diameter and 20 to 25 mic. long. Then may follow a description of the sexual reproductive organs and of the apothecium and its parts. Following this the algal colony in which the lichen grows may be described in a separate paragraph. The description of the Collemaceae as a whole and all the genera and species will need to be modified in similar fashion. What are specific and what are generic characters will appear in the revision. What species will have to be abandoned because of excluding from the descriptions the characters which belong to the algal hosts can only be ascertained by critical study.

The changes required in the descriptions of those lichens which contain the symbiotic algae in a stratum within their thalli will not be so great, and fortunately these lichens are far more numerous

than those in which the lichen ramifies throughout the algal colony. More difficulty will probably appear in the crustose than in the foliose and the fruticose species. In the descriptions of many genera and species of lichens, the only changes needed are to remove whatever is said of the algae from the descriptions and to modify in some manner the statements regarding the so-called algal layer and the soredia. In thalli which contain the algae in a definite stratum, the algal layer may well be called the *haustorial layer*. This has the advantage of excluding from the statement an organism which does not belong to the lichen. The soredium should be regarded as *a tangled mass of lichen hyphae and haustoria.*

Perhaps few botanists had thought that so great changes in the treatment of lichens and consequent difficulties in using the literature of lichenology were involved, unless these plants were distributed to the exclusion of the group Lichenes. The trouble really appears when we consider lichens properly as fungi, whether we distribute them or not; though the less fundamental matter of distribution does offer even more intricate problems. Treating together as colonies the lichens and the algae which occur with them and continuing to describe and classify these colonies is the only way to avoid the enormous amount of labor involved in revision. This is, of course, wholly illogical, and the only consistent course is to break with past methods and treat lichens rightly, regardless of the difficulties which present themselves.

THE BIOLOGICAL RELATIONS OF CERTAIN LOWER LICHENS

By considering carefully some lower lichens and some plants that may not be lichens, we will be able to gain information regarding the relation of lichens to their algal hosts and to other fungi. Those who hold to some form of dual hypothesis insist that these lower and doubtful lichens are atypical and should not be considered; but the largest groups of lichens are among the lowest forms. Hence, the lowest lichens are interesting and instructive in consideration of problems relating to the nature and the disposition of these plants in general. Their study throws light upon phases of the problem which can scarcely be under-

stood so long as we confine attention to the higher foliose or fruticose lichins or even to higher crustose forms.

De Seynes (122, 123) found specimens of *Sclerotinia tuberosa* (Hedw.) Fuck., the hymenial surface of which showed produced ends of paraphyses closely applied to unicellular algae. The results were fully published in 1886, and the figures show that in some instances branching, haustorial elongations of three or more paraphyses are closely attached to a single algal cell. The alga is said to be *Chlorococcum humicola,* which occurs with lichens so commonly. The swollen and turgid haustoria are cut off by a septum and are like those of typical lichens which live with the same alga. But few of the paraphyses are attached to the algal cells. This observation has not been repeated, and the relation of this fungus to the alga is rare and accidental; yet it illustrates the manner in which lichens arose from non-algicolous fungi. Our view of lichens can be construed to make the rare *Sclerotinia* individual which lives with the alga a lichen; but this may better be left to personal judgment. The point regarding the origin of lichens and their relationship to other fungi is as well shown whether we regard these individuals lichens or not.

Archer (3) described and figured lichen apothecia on *Scytonema myochrous, Sirosiphon alpinus, S. pulvinatus* and *Stigonema mamillosum.* The spores are much alike in all of these and strongly resemble those of our *Ephebe pubescens* (L.), Fr., though not the same. He thought perhaps that the lichen was the same on all of these algae, but his spore measurements would indicate otherwise. He found neither hyphae nor sexual organs; but it is very probable that he observed one or more primitive, facultative lichens.

Frank (58) found that *Arthonia radiata* (Pers.) Ach. grows within the periderm of trees, often for years, wholly outside the relation with the symbiotic alga, *Trentepohlia umbrina,* and that some individuals never parasitize the algal host at all. After a time, according to Frank, some of the algae bore into the periderm and are attacked by the lichen, which now grows more luxuriantly, penetrates deeper into the periderm, becomes also partly superficial and produces apothecia. Those individuals that fail to enter into the partnership with the alga do not produce apothe-

cia. Thus it appears that these fungi can live without the algae, but are benefited by the association with them. *Trentepohlia* is known to live commonly in the periderm. Therefore, it seems certain that this alga is often there and enters into the hostal relation with the lichen soon after the lichen spore germinates and penetrates the periderm, though Frank seems to have supposed that these lichens were always independent of the alga during a good portion of their course. More of Frank's results are given toward the close of this paper.

Lindau (81) accepted, in the main, the conclusions of Frank and passed on to a profitable consideration of the same or similar lichens and the algae which grow with them. He found *Trentepohlia* filaments on the surface of the bark entwined by hyphae of *Arthopyrenia punctiformis* (Pers.) Mass.; but the portion of the fungus within the periderm was wholly free from the algal filaments. He concludes that this *Arthopyrenia* lives without other than an accidental relation with the alga.

These researches are interesting and instructive in many ways. Frank decided that typical lichens are Ascomycetes which live in symbiotic relationship with algae; but he regarded all of these plants which belong to the same genus lichens, whether all or only part of them live with the algae. Lindau, on the other hand thinks that those that live outside the symbiotic relation are not lichens. These studies also indicate that the lichen is benefited by the association with the alga quite as plainly as do the cultural experiments with higher lichens; and this makes sure the position that those fungi which live during all or part of their life in parasitic relation with algal hosts are lichens, provided that they sustain, at the same time, the usual relation with an external substratum. Lindau thinks the *Arthopyrenia* considered above is not a lichen, since the alga does not grow more luxuriantly because of association with it. We can not accept this view, but believe that the fungus is a lichen if it is benefited by the association with the alga instead of using it merely as a support about which to twine. We agree with Lindau that those species which do not enter into parasitic relation with algae are not lichens, even though they belong to the same genus with others that enter into relations beneficial to themselves and are lichens. Whether a fungus

species, some of whose individuals run part of their course in the parasitic relation with an alga, while others pass their whole life outside this relation, is a lichen is a rather fine distinction that is doubtful at best and scarcely worth considering. But it seems more reasonable to say that all species that are better developed when they live with algae than when they do not are lichens.

Zukal (151) published an account of the frequent occurrence of one of the Hypocreaceae with an alga which he thought to be *Palmella botryoides*. He named the fungus *Epigloea bactrospora* Zuk. The perithecia are semi-immersed in the algal colony, through which the hyphae ramify and are attached here and there to the algal cells. We have here a pyreno-lichen, belonging to a well known group of Pyrenomycetes. Hence its phylogeny seems certain enough, and it furnishes another point of approach of lichens to other well known fungi. The lichen is so little modified that Zukal placed it near the genus, *Barya*, of the Hypocreaceae; but Zahlbruckner, in Engler and Prantl (145), has removed it from its natural position and has erected for it a lichen family, the Epigloeaceae. The alga is sometimes found free on mosses, and is in other instances attacked by the lichen. However, the occurrence of free algae growing with those of the same species attacked by lichens is known to be frequent, as will be proved later in this paper.

Zukal (152) also published some interesting results in his paper entitled "Halbflechten." Some of these concern his monotypic genus *Parüphrädria* and the species *Parüphrädria heimerlii* Zuk., found on the leaves of *Jungermannias*. The lichen gains entrance to these hepatics through the rhizoids, which it entwines and penetrates. It extends into the outer tissues of the stems and penetrates the leaves, some of which are finally killed. The apothecia usually occur on the leaves and most commonly at points where algal colonies of *Glococapsa* or of *Palmella* happen to be present. Here the lichen hyphae grow through the algal colonies in all directions, but do not penetrate into the algal cells. Microscopic squamules or granules are formed. Zukal considered each of these a lichen thallus. Only a portion of the lichen penetrates into the algal colony; but some parts of lichens are commonly external to the algal mass with which they grow, and

a lichen is a lichen whether this external portion be much or little. We must consider the whole structure, the parts that grow on the hepatic as well as those that grow in the algal mass, a very primitive lichen. The undetermined point of special biological interest regarding the fruiting is whether the apothecia are ever produced before the relation with the alga is established. It matters not that the apothecia are sometimes formed at some distance from the algal colonies, for the nourishment could be carried by the hyphae. In Engler and Prantl, Lindau (82) gets this plant instead of Zahlbruckner, and places it near Bulgaria. Rehm (103) agrees with Lindau regarding the position; but Rehm believes that lichens might well be distributed among other fungi and frequently treats lower lichens with other Ascomycetes. So his stand is not proof that he does not regard this plant a lichen. *Gloeopeziza rehmii* Zuk., another of Zukal's half-lichens (152), produces its apothecia at a distance from the *Gloeocystis* or the *Palmella* masses, into which certain hyphae penetrate and very probably convey nourishment to the points where the apothecia are developing. Zukal says that this lichen passes its early stages as an epiphyte, but not as a parasite, on the leaves of *Jungermannia triophylla;* and it would be especially instructive to know certainly whether the apothecia ever develop before the algal colonies are attacked. Rehm (103) places this lichen with the Bulgariaceae, but Lindau (82) considers it one of the Pezizaceae.

Very different are the conditions in *Nectria phycophila* Zuk., another of Zukal's half-lichens (152), which grows in *Hypheothrix zenkeri,* of the Oscillatoriaceae. The mycelium of the lichen is found in the trichomes of older dead portions of the algal colony; but, in younger portions of the colony, the hyphae occur in the sheaths only. No haustoria were noted; but this fungus, recognized as a *Nectria* by Lindau (82), is as good a lichen as are *Ephebes* or *Collemas* and other lichens in which the relation of the lichen to the alga is not very intimate. One who believes that the lichen consists of the fungus and the alga which grow together can not consistently place this or any lichen with fungi; so this plant can not properly be regarded a *Nectria* by them. Yet, this inconsistency did not occur to Zukal, who regarded the lichen a dual organism; nor does it seem to have troubled many

other mycologists, who treat lichens in general quite as inconsistently. On the other hand, those who believe that lichens are a distinct taxonomic group should, to be consistent, claim this plant, but they have not. The main difficulty disappears when we regard the lichen a fungus. The last difficulty fades for those who maintain that these fungi should not constitute a taxonomic group, but should be distributed in the best manner possible.

Endomyces scytonematum Zuk., the last of Zukal's half-lichens (152), is supposed to be *Ephebe hegetschweileri* Itz. The spores occur in naked clusters of asci, characteristic of the Gymnoascaceae. The lichen hyphae grow for a time in the sheaths of *Scytonema* filaments; but as the asci develop, the hyphae penetrate into the trichomes of the alga, which are soon destroyed. Then follows, of course, the death of the lichen soon after the fruit is produced. Zukal took the position that we have not a lichen in this instance, since the relation is antagonistic and the fungus short lived. But mutualistic symbiosis is surely no *sine qua non* of the lichen and, indeed, seems not to exist at all in those plants. Much less is long life necessary. The early death of the algal host is good proof that the fungus derives benefit from the association with the alga; and the best and, apparently, the only biological criterion for the lichen is that it should live in parasitic relation with an alga and at the same time maintain a relation with some organic or inorganic substratum. According to this standard, we have here a lichen which plainly belongs to the Gymnoascaceae. Of course, it should be left in this group, instead of artificially placing it elsewhere; but in order to do so, it is not necessary to deny its being a lichen.

Tobler (132) investigated a few of the several hundred parasites on lichens. Among these *Karschia destructans* Tobler is described from the thallus of *Chaenotheca chrysocephala* (Turn.) Th. Fr. The *Karschia* penetrates into and through the crustose thallus of the *Chaenotheca,* into the bark on which the latter lichen grows. In passing through the lichen thallus, the *Karschia* hyphae attack and kill the *Chaenotheca* hyphae and the alga which grows in symbiotic relation with them. This gives the *Karschia* a parasitic relationship with the *Chaenotheca,* and with the alga, and a saprophytic relation with the bark and perhaps

with the algal cells after these have been killed. The fruit is produced after the saprophytic relation is established. The relations of the *Karschia* to living and dead sources of food supply are certainly complex enough; but we must conclude that the fungus is as good a lichen as are many other fungi which live in relation with algae during part of their life period only.

Similar are the results of Zopf (146), who studied *Rhymbocarpus punctiformis* Zopf on *Rhizocarpon geographicum* (L.) Lam. and *Conida punctatella* (Nyl.) Zopf and *C. rubescens* Arn. on *Rhizocarpon alboatrum* (Hoffm.)Th. Fr. The *Rhymbocarpus* and both *Conidas* enter into parasitic relationship with the algal hosts within the *Rhizocarpons,* and therefore Zopf very properly regarded them low forms of lichens. He concluded that many other parasites on lichens are likewise primitive lichens.

Elizabeth Acton (1) investigated *Botrydina vulgaris* Breb., growing on mosses and hepatics. The minute colonies, barely visible to the eye, cover the stems and leaves, often so thickly as to conceal them. The sheaths of the globular or irregular colonies are traversed by fungal hyphae. On close examination, these sheaths appear to be cellular. In some cultures, Miss Acton obtained a rich development of fungal hyphae and in others small unicellular algae, the results depending upon the kind of medium used or the conditions under which the cultures grew. The sheaths are very resistant to chemicals and are probably composed of fungus-cellulose. In early stages of development, she found fungal hyphae in contact with the sheaths and concluded that the sheaths develop from the hyphae. Sections showed plainly the plectenchymatous nature of the sheaths and the distorted forms of the algal cells. In one specimen, the fungus was intact, but no algal cells could be detected. The alga was also found free. The fungus is doubtless a lichen, living in parasitic relation with a unicellular alga. The alga is *Coccomyxa subellipsoidea,* of the Palmellaceae; and the lichen, on account of the occurrence of ring-like structures similar to the conidia of the Mucidineae, division Helicosporeae, is supposed to belong to that group. Of course this makes what has been known as *Botrydina vulgaris* Breb. not an alga at all, but a lichen parasitic on an alga. The lichen must be renamed as soon as its nature can be ascertained.

Thus far we have been considering ascomycetous lichens. We may now give attention to a few Basidiomycetes, some of which are lichens while the others may be. Möller (89) found a *Cora*-like thelephore growing abundantly with *Cora*. The two plants are alike in structure as well as in macroscopic appearance. He pulverized portions of *Cora* in water and poured the broth over the thelephores. In three months, *Cora* lobes, bearing the alga characteristic of this lichen, appeared along the margins of the thelephore pilei. Microscopic examination proved that the hyphae of the young *Cora* lobes were continuous with those of the thelephores on which they grew. Thus, by field cultures, Möller transformed part of a thelephore into the lichen, *Cora*. The conclusion is that *Cora* is a primitive lichen, growing beside its non-lichen progenitor, the thelephore. The experiments were extended to *Dictyonema* and *Laudatea* as is explained below in the statement under culture experiments.

Lagerheim (79) published a new subspecies of *Stichococcus bacillaris,* which he found growing on *Polyporus lucidus, Trametes pini* and *Daedalea quercina.* He states that his subspecies *fungicola* is similar to *Stichococcus bacillaris,* found growing with some of the Caliciaceae. He makes no suggestion that the fungi on which his alga grows may be lichens in the making. But there is a possibility that such is the case, and that we have here and in other hymenomycetes upon which algae are frequently seen, very primitive lichens, or at least accidental and indifferent associations of algae with fungi which may become lichens in time.

Morgan (86) noted the constant occurrence of *Clavaria mucida* with *Chlorococcum humicola.* Coker (38) observed the same relation of the alga to the fungus. On examination, he found that the hyphae ramify through the algal masses. There are no haustoria, and he regards the relation of the fungus to the alga about the same as that of *Collema* to the *Nostoc* colonies in which it grows. The relation is almost certainly advantageous to the fungus, and Coker's conclusion that *Clavaria mucida* is probably becoming a basidiomycetous lichen seems reasonable.

We may now pass to some unknown fungi which may be lichens. Schneider (114) investigated the relationship of *Trentepohlia aurea* to some unknown fungus. He found the fungal

hyphae closely applied to all of the *Trentepohlia* filaments examined, forming a delicate, reticulated, spirally wound network of hyphal tissue, entwining the filaments from the base to the apex and extending a short distance beyond. This fungus is probably a primitive and imperfect lichen, the fruit of which is unknown. Of course, it is possible that the fungus bears no nutritional relation to the alga, but merely uses it as a support, on which to climb. If so, the fungus is not a lichen; but this supposition is improbable.

One sometimes finds *Sirosiphon* filaments attacked by other fungal hyphae than those of *Ephebe*. These hyphae are usually external, while those of *Ephebe* ramify through the algal filaments. These superficial hyphae bear somewhat the same relation to *Sirosiphon* as do those found by Schneider to *Trentepohlia aurea,* and they may represent some unknown lichen or lichens. The findings of Archer, given above, may well be recalled here.

Many botanists have not known that the transitional forms connecting lichens with other fungi are numerous; but among the Graphidaceae, the Arthoniaceae, other families of lower lichens and the fungi parasitic on lichens are hundreds and probably thousands of species whose biological position can only be known by careful research. Besides these, there are doubtless many more accidental associations of fungi and algae yet to be discovered. In view of these facts, the bridges connecting lichens with other fungi seem to be very numerous.

Whether a given fungus is a lichen is of little, if any, biological importance, and is certainly of no taxonomic importance for those who believe that lichens should be distributed to the exclusion of the group Lichenes. But the biological relationship between fungus and alga is an important one, and the fungi which are partners in it will continue to be known as lichens. Hence, from a biological point of view, it is important to reach some conclusion touching what constitutes a lichen. However, the main object of this discussion is to bring to light some of the very close but little known relationships of plants on the border line between lichens and other fungi. One may regard these as lichens or not. The relationship remains the same in either case, and research must discover many more such relationships before our knowledge of

the species which form the connections between lichens and other fungi will be at all satisfactory.

The lichen may be defined thus: *A lichen is a fungus which lives during all or part of its life in parasitic relation with an algal host and also sustains a relation with an organic or an inorganic substratum.* It need scarcely be pointed out that this definition is a biological rather than a morphological one, and that we are treating lichens from a biological rather than a morphological or a taxonomic point of view. Our definition denies the mutualism hypotheses, to one of which some of us have adhered for many years; nor does it meet very well the requirements of those who hold that the group Lichenes should be retained. Of course, the lichen is usually parasitic on many individuals of some species of alga, instead of living on a single individual. One may speak of the alga or the algal host, meaning the species on which the lichen is parasitic, or one may, with equal propriety, speak of the algae or the algal hosts on which the lichen is parasitic, meaning thereby the individuals. The definition above follows the first method. Likewise, as pointed out by Bonnier (31), Friederich (59), Stahlecker (125) and Zukal (149), what is called a lichen individual is often compound, being composed of a number of simple individuals united. Our definition defines the simple individual. Again, the lichen is probably partly saprophytic on the alga. It does not seem necessary to recognize this point in a definition of the lichen, for the present at least. One or two of Zukal's half-lichens are not known to sustain the relationship with the external substratum and if they do not, may be excluded from lichens on this account.

THE ALGAL HOSTS OF LICHENS

For some of us, it would not be necessary to consider the nature of lichens further; but for those who still cling to the dual hypothesis, the last word will not be said until the relation of the lichen to its algal host has been thoroughly reviewed. A considerable number of algae have been enumerated as lichen hosts, but most of these rarely or never function as hosts for lichens. Fünfstück (64) gives ten algae known as lichen hosts. These are *Chlorococcum* (*Cystococcus*) *humicola, Palmella botryoides,*

Trentepohlia (*Chroolepus*) *umbrina, Pleurococcus vulgaris, Dactylococcus infusionum, Nostoc lichenoides*(?), *Rivularia nitida, Polycoccus punctiformis, Gloeocapsa polydermatica* and *Sirosiphon pulvinatus*. Of these the larger number are blue-green algae, yet the two species of green algae, *Chlorococcum humicola* and *Trentepohlia umbrina,* form the hosts of many more lichens than all the others combined. So far as the writer knows, *Palmella botryoides* is the host of only one little-known lichen, viz., *Epigloea bactrospora* Zuk.; and there is better reason for including among lichen hosts one or more *Scytonemas* which are algal hosts of the better known *Dictyonemas,* also of one of Zukal's half-lichens, and may sometimes be the host of *Stereocaulons* as well. Only a few lichens are known to live facultatively on different algae, most lichens being obligative parasites. *Lecanora granatina* Sommerf., *Solorina crocea* (L.) Ach., the *Cypheliums, Pannaria tryptophylla* (Ach.) Mass. and probably a few others are facultative. The facultative species are either those which have never settled upon a definite host, or those which are changing from one host to another. But such change is probably rare and so slow a process as scarcely to come within the range of observation.

Lichens usually parasitize terrestrial algae which grow in habitats commonly invaded by lichens. This accounts for the small number of algal hosts of lichens. It is well known, as will be brought out below, that lichens frequently attack free algae and that parasitizing algal individuals or colonies, of species which have long formed lichen hosts, is going on constantly. On account of the modification of the algal hosts, due to parasitism, there is still some uncertainty regarding certain species of algae that serve as lichen hosts; and it would not be strange if the number of closely related species that function as such hosts is larger than we now suppose. Lichens are known to parasitize approximately one per cent. of known species of blue-green algae and a very much smaller proportion of the numerous green algae.

FINDING THE ALGAL HOSTS GROWING NEAR LICHENS

Schneider (111) thinks that the spores of lichens are degenerate and do not often function for reproduction. We often find algae which, under the microscope, show plainly the presence of

attached fungal hyphae, but Schneider thinks that these are not the primordia of any well-known higher lichens. Hicks (67) found that if a piece of bark supporting *Chlorococcum* is kept under glass in a moist place, the groups of algal cells seem to become transformed into a felted mass. We now know that the same thing is often observed in nature, lighter felted masses often appearing where *Chlorococcum* has been growing. Microscopic examination shows that the color change is due to the development of lichen hyphae. These hyphae appear more commonly when the alga grows near some lichen, and it may take years for the felted, mycelial masses to develop into mature lichen thalli.

We have observed, in our laboratory with our students, minute *Nostoc* colonies, germinating *Collema* spores, other *Nostoc* colonies penetrated by one or more germ tubes of spores, and various stages of development of *Collemas,* all growing together. When first parasitized by the lichen, the *Nostoc* colonies are of normal form; but as the lichen develops within, the algal colonies become greatly modified in form. The *Nostoc* colonies are usually parasitized when only 50 to 200 mic. in diameter.

Likewise, Schwendener (119) records finding free *Nostoc* colonies, others penetrated by several *Collema*-like hyphae, young but undoubted *Collemas* on scarcely modified *Nostoc* colonies, and older *Collemas* on much modified *Nostoc* colonies, all growing together in the field. He also found similar relations between *Leptogium subtile* (Schrad.) Koerb. and *Nostoc* colonies, between a species of *Placynthium* (*Racoblenna*) and *Rivularia,* between *Ephebe pubescens* (L.) Fr. and *Sirosiphon,* and between *Spilonema paradoxum* Bor. and the same alga. Kny (72) recorded finding *Lichina pygmaea* Ag. and its algal host, *Rivularia nitida,* growing in proximity in the same clusters, in some portions of which the *Rivularia* individuals were all free, in others all parasitized by the lichen, and in still other portions, partly free and partly parasitized.

Bornet (33) found *Trentepohlia umbrina* forming the algal host of *Opegrapha varia* Pers. and also growing on the branches of trees about the lichen, but separate from it, both on the outer surface and within the periderm. Toward the margin of the

thallus of this *Opegrapha,* he noticed loosely felted hyphae within the periderm and upon the surface, the hyphae becoming scarce at the margin. Where these hyphae encounter free *Trentepohlia* filaments, they become attached to the algal cells. He found the same relationship between *Trentepohlia* and *Pyrenula nitida* (Weig.) Ach. and also recorded finding the *Trentepohlia* filaments from within the lichen thallus extending into external filaments, which produced zoöspores while still attached to the lichen. He also found that the same alga produces zoöspores within the thallus of *Opegrapha varia* Pers., and that the lichen hyphae are often attached to zoösporangia of the algal host. The same worker found the algal host of *Pannaria nigra* (Huds.) Nyl. extending into external filaments, which sometimes become free from the lichen. Like de Bary, he found *Nostoc* parasitized by *Collema,* but showing minute tubercles, often nearly cut off from the lichen. Some of these tubercles become free and form minute, non-parasitized *Nostoc* colonies, at first not over a half millimeter in diameter. Zukal found *Palmella botryoides,* both free and parasitized by the lichen, *Epigloea bactrospora* Zuk.

Cunninghan (43) and Ward (138) both studied the relationship of *Strigula* to its algal host and to the leaves on which the lichen and its algal host grow together. Cunningham found that the lichen produces fruit only after parasitizing the alga, and that the alga forms zoöspores, oögones and antherids only when free from the lichen. Ward found the leaves of *Michelia fuscata,* especially during the rainy season, to contain networks of branching mycelia of *Strigula complanata* (Fée) Nyl. These mycelia are composed of brown, septate, branching hyphae, spread over the leaf-surface without haustorial attachment. They rise from oval, brown, two-celled ascospores, and often produce clusters of brown conidia. A *Trentepohlia*-like alga also grows here and there on the leaves, and the algal groups are often overgrown by these mycelia, which produce the conidia where they come in contact with the algae. The hyphae gradually penetrate into the algal masses, destroy them, and in the meantime produce spermagones and later perithecia. The lichen sometimes parasitizes the alga while the latter is very young, and the algal host is soon

killed, the lichen producing conidia but neither spermagonia nor ascospores. But when the attack comes later, it takes longer to kill the alga, and the lichen produces spermatia and ascospores. Finally, some of the algae run their whole life history without being attacked by the lichen.

Nylander (97) held that he found lichens most abundant where algae are absent; but he doubtless based his statement on an erroneous impression and not on careful observation. Peirce (98) finds commonly on old fences free algal cells, others invested by hyphae and so on up to mature lichens of various species common in his region. Williams (141) observed that lichens appear first in damp places, where algae are most numerous, and spread gradually from these to other locations. He found that they grow first on the shady and moist parts of trees and fences and rarely if ever appear first on dry, wind-exposed portions. These observations of Peirce and Williams agree in general with what the writer has noted many times, though there is no doubt that lichens will grow in very dry places.

We have many times found the algal clusters which proved to be parasitized by fungal hyphae, growing both in the vicinity of lichens and in other moist places, but have not been disposed to agree with Schneider that these are necessarily the primordia of very primitive lichens. It has seemed more reasonable to suppose that they may be young conditions of higher as well as of lower lichens which are present in mature form near by. Years of observation of the development of these primordia should give valuable results, whether growing in the vicinity of lichens or elsewhere.

Nylander (94) mentioned algae occurring in the hymenia of pyrenomycetous lichens. Fuisting (62) found that in *Stigmatomma cataleptum* (Ach.) Koerb. the hymenial algae are certain algal host cells, which become imprisoned in primordia of apothecia and multiply as the apothecium develops. Winter (143) agreed in general with Nylander and Fuisting, all three finding that the hymenial algae are smaller than other algal host cells; but Winter noted in addition the paler color of the former. These hymenial algae occur in early stages of development, or in

old apothecia of many lichens; but they seem to be especially characteristic of pyrenomycetous lichens, particularly those that have muriform spores. Stahl (124) found them in *Endocarpon pusillum* Hedw. and in *Polyblastia rugulosa* Mass. and proved that, in these lichens, they are ejected with the spores, which soon germinate and attack the algae. Little is really known about the frequency of occurrence of hymenial algae at the time that spores are ejected; but it is probable that this is not uncommon in those pyrenomycetous lichens which are not able to live a considerable length of time outside the parasitic relationship with an algal host. Hymenial algae perform somewhat the same rôle as the algae in the soredia of higher lichens; and since they occur in lower lichens, while the soredia are more common in higher lichens, each of these provisions for reproduction supplements the other. Even in lichens that have neither soredia nor hymenial algae, there is no difficulty about reproduction through lichen hyphae coming in contact with algal host cells. Since spores blow long distances, this could happen whether lichens grow near the algal hosts or not.

These various observations regarding lichens growing in proximity with their algal hosts prove that lichens may frequently originate from spores which germinate and attack free algae; and it must be borne in mind that the spores may remain dormant for a considerable length of time until conditions favorable for germination are at hand. Such observations also show that both the algae and the lichens may grow separate from each other, the former throughout their whole life and the latter sometimes during a considerable time, very probably years in some instances. Such results make the consortium hypothesis wholly invalid, and seem to have been overlooked, underestimated or misinterpreted by those who hold to that hypothesis.

CULTURES OF LICHENS WITH OR WITHOUT THE ALGAL HOSTS

Alfred Möller (87) cultivated *Lecanora subfusca* (L.) Ach., *Thelotrema lepadinum* Ach., *Pertusaria communis* Lam. and DC., *Graphis scripta* (L.) Ach., *Buellia punctiformis* (Nyl.) Hoffm., *Lecidea enteroleuca* Ach., *Opegrapha subsiderella* Nyl., *Arthonia*

vulgaris Schaer., *Calicium parietinum* Ach., *Calicium trachelinum* Ach., *Calicium curtum* Borr. and Turn. and *Verrucaria muralis* Ach. from spores, from spermatia, or from both spores and spermatia, without the algal hosts. The following five, *Buellia punctiformis* (Nyl.) Hoffm., *Opegrapha subsiderella* Nyl., *Calicium parietinum* Ach., *Calicium trachelinum* Ach. and *Calicium curtum* Borr. and Turn. were cultivated from both spores and spermatia. With *Graphis scripta* (L.) Ach., he obtained hyphal tangles which he regarded primordia of apothecia, or of spermagonia; but the purpose of his work was not to determine whether apothecia can be produced when the lichen is grown without the algal host, and some of these crustose lichens might have fruited, had the cultures run more than a few months. Again, he might probably have obtained apothecia, had he worked on *Endocarpon pusillum* Hedw. or *Polyblastia rugulosa* Mass., which are known to mature and to produce apothecia from the spores in two or three months. He tells very convincingly of obtaining spermagones in cultures of *Calicium parietinum* Ach. in five or six weeks, from spores and from spermatia. Beginning with spermatia produced in pure cultures, he obtained several successive generations of thalli by the germination of these bodies, and thus proved that the ascopores and the spermatia belong to the same plant. He also obtained spermatia in nearly all of the cultures and got them to germinate and produce new thalli of the same kind as those on which they were produced. His results indicate that these structures are either asexual conidia or male cells which have the power of reproducing parthenogenetically. In further studies Möller (88) obtained branched germ tubes from the spermatia of *Collema microphyllum* Ach.

Möller is not the only one who has caused spermatia of lichens to germinate, but we must now pass to some observations by Hedlund (66). He found spermatia of *Catillaria denigrata* (Fr.) Hedl. and *C. prasina* (Fr.) Th. Fr. which had germinated on the natural substratum among mature and variously developed states of these lichens and the free algal hosts. The mycelium produced by the spermatia was growing alone in some instances, while in others it had parasitized some of the algae. The latter lichen

showed many intermediate conditions between the young mycelia produced from the germinating spermatia and the mature plants with spermagonia and apothecia. The spermatia germinating on the substratum were compared with those found in the spermagonia and were like these and also like those germinating on the thalli about the spermagonia. These results confirm those of Möller and are also interesting because they give further evidence of lichens growing with the algal hosts and reproducing by germinating upon them.

Bornet's classic results (32) are well known. He grew lichens from spores and found that they readily attack their algal hosts, while those that do not come in contact with the algae soon die. Of course he did not use proper media, or his lichens might have grown longer without the hosts; but this failure matters not for our purpose. He grew species of *Collema, Arnoldia* and *Physma chalazanum* (Ach.) Arn. with *Nostoc* colonies, *Synalissa* and *Omphalaria* with *Gloeocapsa, Ephebe* with *Sirosiphon, Opegrapha varia* Pers., *Roccella phycopsis* Ach. and *Pyrenula nitida* (Weig.) Ach. with *Trentepohlia, Opegrapha filicina* Mont. with the *Coleochaete*-like *Phyllactidium* and a number of lichens with *Chlorococcum humicola.* He found *Pannaria tryptophylla* (Ach.) Mass. to grow with two algal hosts, a *Nostoc* and a *Scytonema.* Both of these algae often occur with the lichen in nature, and both often are found in the same lichen thallus. He also found *Trentepohlia* and *Phyllactidium* free in the vicinity where *Roccella, Opegrapha* and *Verrucaria* were growing. *Opegrapha filicina* Mont. is an ectoparasite, and some other lichens are also ectoparasites, but on unicellular or filamentous algae, among which the hyphae grow without penetrating into them. For instance, there is no connection between the *Collema* hyphae and the *Nostoc* filaments; and the *Collema* is ectoparasitic, except for penetrating into the gelatinous envelopes of the *Nostoc* colonies. The *Nostoc* individuals are nearly normal, but the colonies are much modified in form. Bornet also found *Pannaria muscorum* (Ach.) Del., *Lichina confinis* (Smith) Ag. and *Heppia urceolata* Näg. parasitic on two algal hosts, the last two with *Chlorococcum humicola* and a blue-green alga. He found that the other lichens

studied attack the cells of the algal hosts directly; and in such instances the algal cells or filaments are so modified or broken up that the nature of the algal host is difficult or impossible to ascertain. But where the union of hyphae with algal-host cells can not be seen, the latter are little, if at all, modified. In this connection, it may be added that Bornet saw his algae growing in the usual form and also modified by the lichen parasites, and so established that the modification is not phylogenetic but comes about rapidly. He referred his algal hosts to the genera *Trentepohlia, Phyllactidium, Chlorococcum, Pleurococcus, Dactylococcus, Ulothrix*(?), *Cladothrix*(?), *Scytonema, Nostoc* and *Oscillatoria*. These are nearly all cosmopolitan algae, to be expected on barks, earth, bases of mosses and in cracks and crevices where lichens may begin development from spores and attack their algal hosts.

Treub (135) caused lichen spores to germinate in pure cultures in the hope that he might develop the green cells from the hyphae. Of course he failed in this. Then he made cultures from spores of *Xanthoria parietina* (L.) Th. Fr., *Ramalina calicaris* (L.) Fr., *Lecanora subfusca* (L.) Ach. and *Physcia pulverulenta* (Schreb.) Nyl., with the algae present and found that the germ tubes of the spores lay hold on the algae. He used wild *Chlorococcum humicola* and obtained the same results as when he took the algae from lichen thalli. He thus proved that the germinating spores may readily attack free algae, as would be inferred from the fact that lichens so frequently grow in the vicinity of the free algae. He got the hyphae to branch freely after attacking the algae, but did not get fully developed thalli. Borzi (34) made cultures of *Physcia pulverulenta* (Schreb.) Nyl., *Physcia ciliaris* (L.) Ach., *Xanthoria parietina* (L.) Th. Fr. and *Pertusaria communis* Lam. & DC. with algae, and concluded that these lichens are Ascomycetous fungi and are parasitic on the algae with which they grow.

As briefly outlined above, Möller (89) found a small white thelephore growing with the lichen, *Cora*. The fungus rarely occurs elsewhere than on the same substratum and in the same locality with this lichen. The general structure is the same in both plants, and their spores behave alike in germination. He

pulverized portions of the lichen in water and poured the broth over thelephore plants. In three months there appeared on lobes of the non-algicolous plants thus treated, and only on these, typical algicolous *Cora* lobes. By microscopic examination, he found that the pulverized lichen tissues did not grow; but rather that the thelephore hyphae attacked the algae and became transformed into *Cora* lobes, which appeared only at the margin of the thelephore, where its hyphae came in contact with the algae. In some instances the algae were left behind in time, and the *Cora* lobes reverted into thelephore forms. Thus he effected in nature the transformation of a non-algicolous into an algicolous fungus (lichen), and vice versa. Microscopic study proves that the spores of *Dictyonema, Laudatea* and *Cora* are alike, and behave exactly alike in artificial cultures. The thelephore which passes into the *Cora* form when it parasitizes *Chroococcus* grows into *Dictyonema* or *Laudatea,* according to conditions of habitat, when it parasitizes *Scytonema, Dictyonema* being confined to small branches not more than finger-thick, and *Laudatea* occurring on larger branches, on dead wood, on leaves, on mosses, or on liverworts. Transitional forms between *Dictyonema* and *Laudatea* occur commonly. *Cora* forms grow from *Dictyonema* lobes, and the thelephore is found growing from *Cora* lobes and from *Dictyonema* lobes. *Laudatea* grows on *Dictyonema* lobes, or on *Cora* lobes, in response to change in algal host. Fungus individuals growing on the spherical cells of *Chroococcus* would be modified less and in a different manner from those growing on *Scytonema* filaments, and so *Cora* is more like the thelephore than are *Laudatea* and *Dictyonema,* which are more modified on account of the nature of the algal host. We may still regard the genera *Cora, Dictyonema* and *Laudatea* distinct from each other and from their thelephoric progenitor, though any one of these may be produced from any other one in a short time by absence or by modification of the relation with an algal host. Yet this taxonomic distinction can not be insisted on very strongly. Möller's research shows plainly that it would be absurd to regard such lichens anything but fungi. Nor do other lichens behave so differently toward their algal hosts as many botanists have supposed.

Bonnier (31) seems to have been first to produce mature, fruited lichens in cultures. He raised *Xanthoria parietina* (L.) Th. Fr. with an alga which he called *Protococcus* and succeeded in getting a thallus that bore an apothecium. With the same alga, he obtained fully developed thalli of *Physcia stellaris* (L.) Nyl. and *Parmelia acetabulum* (Neck.) Dub., but he got no apothecia in these. He sowed *Rinodina sophodes* (Ach.) Koerb. with *Pleurococcus* and got well-developed thalli with apothecia. *Lecanora ferruginea* (Huds.) Nyl., *Lecanora subfusca* (L.) Ach., *Lecanora coilocarpa* (Ach.) Nyl. and *Lecanora caesiorufa* (Ach.) Nyl. grew to maturity with the same alga in two to four years, but none of these produced fruits. Unless he was mistaken in his alga, the algal host was not only wild but also unusual; but he might easily have mistaken *Chlorococcum* for *Pleurococcus*. Spores of *Opegrapha vulgata* Ach. sown with *Trentepohlia* produced good thalli as did also *Verrucaria muralis* Ach., in less than a year. He got *Lecanora atrorufa* Ach. spores to germinate on *Trentepohlia* and *Lecanora subfusca* (L.) Ach. spores on *Vaucheria sessilis*. The former showed haustoria and a poor development of plectenchyma, but the latter produced the plectenchyma only. All of these were cultures with wild algae, and prove that these algae are quickly modified, when parasitized, into the forms usually found in lichens.

Tobler (130) cultivated *Xanthoria parietina* (L.) Th. Fr. with and without an alga. He found that when the lichen grew alone, the yellow parietin was not developed; and treatment with acids and alkalis did not produce the characteristic coloration. In cultures of the same age with the alga, he got the yellow parietin and the characteristic chemical reactions. Zopf (148) has summarized these peculiar chemical reactions and the colors produced in lichens, and Tobler's results indicate that all of these chemical reactions and colorations are due to the peculiar relation of the lichen to the algal host, the former plant not being able to produce them alone. So the lichen differs from other fungi in the production of peculiar substances when it grows with the host.

The greatest advantage of parasitism on the algal host has been supposed to be that the lichen received carbon, which the alga

obtained from the air. But now, through another work of Tobler's (132), reinforced by some other researches, it appears reasonable to suppose that the lichen may furnish the alga a portion of the carbohydrates which the former receives from the substratum. Tobler cultivated *Xanthoria parietina* (L.) Th. Fr. and some other lichens without algae in a beerwort-gelatine medium and got a rich production of calcium oxalate. He then grew the thalli with the algae and was not able to find the oxalate. Therefore, he supposes that the algae use the surplus extracted from the medium by the lichen, and that the same thing may occur in nature, the lichen taking the oxalate from the organic substratum. Tobler also started *Xanthoria* on gelatine and transferred it to a liquid medium which contained none of the carbon compounds needed by the alga, except what was contained in the air, and the lichen grew somewhat. The alga increased in the same liquid medium and was of normal appearance. In transferring the lichen, particles of the gelatine were unavoidably carried over. After these were probably consumed by the lichen, the alga was introduced into the culture with the lichen and grew well, but was colorless. This he thinks indicates that the lichen had assimilated the acid, probably oxalic, which the alga needed as a source of carbon. He says that gelatine is not a source of carbon for the alga, so that his conclusions would not be invalidated even if the lichen had not extracted all of this substance from the medium before the alga was introduced. The lichen hyphae soon entwine some of the algal cells in the culture, and thus the parasitic relationship is established. Tobler believes that the lichen obtains carbon from the alga, while the latter replaces it by extracting carbon from the oxalic acid contained in the tissues of the lichen. This would mean an exchange of food particles between the lichen and its algal host in the cultures. While this may be true in his cultures, it could scarcely be so in instances where the lichen grows on rocks that contain no organic matter. But organic substances accumulate very soon, on or in all exposed rocks; so all rocks on which lichens grow may have sufficient organic matter. However, there is no certainty, if indeed any probability, that the physiological relation of the lichen

to its algal host is, in nature, like what occurs in cultures. It is more probable, after all, that the lichen simply carries from the substratum whatever food it gives to the algal host. Yet the lichen may assimilate, or at least digest, some of this food before it is used by the algal host. Tobler obtained the same results with *Pertusaria communis* Lam. & DC. and *Parmelia acetabulum* (Neck.) Dub. So the conclusion is that the lichen produces the oxalate in the cultures, and that the lichen consumes it in each instance. Multiplying instances of such action in cultures can not give us certain knowledge of what happens in nature.

The only certain thing shown by these experiments is that the lichen stores up substances when growing alone in cultures, which are not stored when it grows with the alga, since this host plant uses these substances as a source of carbon. In *Pertusaria* and *Diploschistes*, Tobler found oxalic acid cystals present in thalli which contained algal host cells. He supposes that, in these and other lichens that have thin cortices, the algal host secures sufficient carbon from the air and does not utilize that secured by the lichen from the substratum. In lichens that have thick cortices, the alga would have greater difficulty in securing carbon from the air and would be more likely to depend in part, or perhaps wholly, on materials taken from the substratum by the lichen.

THE GROWTH OF LICHEN HOSTS AND OTHER ALGAE IN PURE CULTURES

Treboux (133) found that species of *Chlorella*, *Pleurococcus*, *Cystococcus* and some other algae are able to obtain carbon in a very different manner from that known in higher green plants. These algae are able to thrive on artificial media containing organic acids, and so he reached the conclusion that they behave like fungi with respect to carbon assimilation. Artari (7) grew *Chlorococcum humicola*, obtained from the thalli of *Xanthoria parietina* (L.) Th. Fr. and *Placodium murorum* (Hoffm.) Ach., in pure cultures on complicated media containing mineral salts or organic compounds, or in some instances, both the mineral salts and the organic compounds. He found that the alga grows and multiplies luxuriantly on the media containing organic matter and is dark green in color, though grown in absolute darkness or in light with

CO_2 excluded. On media containing mineral salts but no organic matter, the alga grows, but not so well. These results square beautifully with those of Tobler on one of the same plants, one worker giving special attention to the lichen and the other confining himself to the algal host. The two researches prove that the alga which lives in the thallus of *Xanthoria parietina* (L.) Th. Fr. can obtain its organic matter and its mineral salts from the lichen. Radais (110) cultivated *Pleurococcus vulgaris* in total darkness on media containing albuminoids or hydrocarbons and found that it can utilize these substances as do saprophytic fungi and bacteria, and that it grows as rapidly and produces chlorophyll as well as in its ordinary habitat. The chlorophyll was analyzed with the spectrum and was found to be normal. So far as they go, these results confirm those of Treboux and Artari. Beijerinck (19), Bouilhac (51), Etard (51), Klebs (71) and others have also obtained results with algae in pure cultures, somewhat similar to those of Treboux and Artari. Two of these workers studied blue-green algae, which behave in the same manner as the green algae.

Beijerinck (19) cultivated the algal host of *Physcia* in elm-bark gelatine, with malt extract added. This alga, *Cystococcus* according to his results, he thinks, is not common in his region, except as the host of lichens, but is replaced in free nature by *Pleurococcus*. The *Cystococcus* was found to have no vacuole or pyrenoid, though other authors seem to find both vacuoles and pyrenoids in algae growing in lichens. The alga produced zoospores in pure cultures, freed from the lichen. His results are valuable, but it is very doubtful whether he found an algal host of lichens which is not common in the free state in the same region. Baranetsky (14) cultivated thin sections of *Collema pulposum* (Berhn.) Ach. and the portion of the algal colony contained. He got young *Nostoc* colonies, which grew rapidly, while the lichen died. He obtained similar results with *Peltigera canina* (L.) Hoffm. Famintzin and Baranetsky (54) isolated algae from the lichen parasites, and the algae produced 30 to 60 zoospores after the manner of free *Chlorococcum humicola*. They worked also on the hosts of *Xanthoria parietina* (L.) Th. Fr., *Evernia fur-*

furacea (L.) Mann and *Cladonia* sp. with similar results. Finally, they found the same algae growing free with lichens in their natural habitats and secured zoospores in similar manner from these.

Itzigsohn (69) made cultures for the purpose of ascertaining the systematic position of *Peltigera*. He found that the algae could be cultivated independently, and that they are blue-green, 20 or more cells often cohering in the cultures in chain-like form, resembling *Anabena*, while in other instances the cells are arranged in colonies resembling *Chroococcus*. Woronine (144) isolated the algae from *Physcia pulverulenta* (Schreb.) Nyl. and obtained 30 to 40 zoospores from each individual in the cultures.

It will be noted that the last section also gives something concerning cultivation of the algae separately, the two kinds of cultures often going on in such a manner that the results are best given together. Those who hold to the mutualism hypothesis have claimed that the algal hosts of lichens are more difficult to cultivate than the same species of algae when free, but there is nothing to indicate that this is true.

THE GROWTH OF LICHEN HOSTS AND OTHER ALGAE ON MEDIA WITH LIGHT OR CARBON DIOXIDE EXCLUDED

Reference was made to this matter in the last section above, in an incidental manner. Treboux (133) found organic acids to be the source of carbon for a number of algae in cultures in total darkness. Some of the 40 algae used are *Stigeoclonium tenue, Scenedesmus obtusus, Raphidium polymorphum, Stichococcus bacillaris, Pleurococcus vulgaris, Chlorella viridis, Chlorococcum humicola, Haematococcus pluvialis, Euglena viridis* and the algal hosts of *Peltigera* sp. and *Xanthoria parietina* (L.) Th. Fr. Of the 40 algae, about half were found to assimilate from media containing organic acids, some growing better with one acid, others with another. He concluded that there is no such sharp distinction between fungi and algae with respect to carbon assimilation as had been supposed, the former probably being able to extract carbon from a larger number of organic compounds than the latter. Then the method of assimilation for the lichen and its algal host may not be so different after all. Whether terrestrial

algae take much carbon from the substratum, except in cultures, may well be doubted. It is scarcely likely that they live a purely saprophytic life in nature as they may be made to do in artificial cultures. It is, on the other hand, much more reasonable to suppose that algae confined in lichen thalli accomplish part of their carbon assimilation saprophytically in the absence of abundant light and air. Lindau (81) noted that *Trentepohlia* seems to flourish better in darkness of deep layers of bark than in the better lighted portions; and it is reasonable to suppose that those algae which live in the bark of trees are nourished somewhat like fungi, whether serving as algal hosts for lichens or not.

As stated above, Artari (5) found that the algal hosts of *Xanthoria parietina* (L.) Th. Fr. and *Placodium murorum* (Hoffm.) Ach. grew on peptone and sugar containing media in absolute darkness and in light with CO_2 excluded, and remained dark green for the time that the cultures were run,—about one half to two and one half months. These algae grow well on mineral salts under the same conditions, but not so luxuriantly, and are usually pale green on these salts. In such cultures, the peptone doubtless serves for nitrogen and the sugars for carbon. Artari tried several modifications of media with varying results. This confirms again the view that the algal hosts of lichens are not very dependent upon light or air. Yet it is doubtless true that the algae in lichen thalli work at a disadvantage on account of scarcity of light and air, and could perform carbon assimilation better with both of these present in larger quantity, such forms as *Trentepohlia* being excepted perhaps. Artari (6) carried on similar experiments with *Stichococcus bacillaris*, the algal host for certain lichens, with results like those stated above.

Regarding the general relation of lower algae to carbon assimilation, Artari's final conclusion (7) is more extreme than might be expected. He thinks that these plants are more dependent upon the nature of the substratum for chlorophyll production than upon either light or CO_2. He found that certain lower algae remain colorless on certain media with light and CO_2 admitted, but are deep green on other media with light and CO_2 absent. This rather independent relation of such plants to light and CO_2

adds to the ease with which some terrestrial algae may have assumed the hostal relation with lichens. It shows that these algae need not have undergone any great change in method of nutrition since becoming lichen hosts. Again, according to this, certain algae may at any time become hosts of lichens without any pronounced nutritional change, the modification being almost entirely morphological and physiological, due to the effect of the lichen upon form, size and functioning of the algal cells or filaments.

It is plain enough that these results from physiological researches are in part conflicting, and that more investigation is needed.

BREATHING PORES AND OTHER MEANS OF AERATION FOR LICHENS AND THEIR HOSTS

Breathing pores have been postulated for lichens, and their existence in crude form in some lichens is no longer to be doubted. Yet their general presence is not proved. Fünfstück (64) gives a general summary in Engler and Prantl. Rosendahl (107) says that *Parmelia aspidota* (Ach.) shows numerous wart-like elevations. These are at first small and closed above; but they enlarge and open later, so that there is free communication between the interior of the thallus and the external air. The openings are formed by a loosening of the hyphal tissue of the plectenchymatous cortex, so that they are not definite canals, but passages through networks of hyphae. He found no such system in any other of fourteen species studied from the same genus and concluded that its presence in *Parmelia aspidota* (Ach.) is correlated with the unusually thick cortex of this species. Zopf (147) has described a new species of *Ramalina* which has similar structures. Aside from such passages which are known in very few lichens, there are several possible ways of entrance. Air may enter through growing points, where the cortex is only one or two layers of loosely interwoven hyphae, and through the lower sides of thalli that have no lower cortices or very thin or incomplete ones. In thalli with uneven upper surfaces, the cortex is often very thin over the elevations, where air may enter. Other

thalli have cracks, through which air may readily reach the medulla. Soralia, cyphellae and empty spermagones furnish avenues, through which air may enter. Isidioid branchlets have thin cortices at their summits, through which air may gain entrance. Hollow cylinders in the center of certain fruticose thalli serve as air chambers, and these are sometimes in direct communication with the exterior through dying away of the basal portions of the branch.

The most extended studies are those of Zukal (153). This worker thought that the hyphae of the medulla of lichens, on account of their branching and elasticity, might be well adapted for retaining air in the interior of the thallus, and for giving it up to the tissues of the lichen and the algal host as needed. The cortex of many lichens becomes pure white after the surface has been moistened, the coloration being due to the air retained within the plectenchyma. When the cortex is brought into water under cover glass on a slide, treatment with alcohol is necessary to drive out the air, the numerous air bubbles disappearing rather slowly. Since the plectenchyma of the cortex admits air with great difficulty, Zukal supposed that the hyphae of the medulla must pass the air admitted to the interior of the thallus upward to the algal host cells. The difficulty with this is that it makes aeration dependent upon such crude makeshifts for getting the air into the interior of the thalli as have been enumerated above, and these do not seem sufficient for adequate exchange of gases for the algal hosts.

Zukal found that when he placed a crustose lichen in glycerine or clove oil and observed with high power hand lens, he saw black, glistening air bubbles under the liquid at numerous points where the atmosphere seemed to be in easy communication with the medulla. This he was able to demonstrate for hypophloeodal and for hypolithic crustose lichens as well as for those above the substratum. He also found that if thin sections through the thallus of a lichen that is parasitic on a gelatinous alga be dried and brought into water-free glycerine, a large number of black, air-containing lines and dots appear in the transparent mass. These black lines and dots pierce through the sheaths of the gelatinous *Nostoc* or *Gloeocapsa* colonies and often follow the

lichen hyphae and the trichogynes. His observations with dry sections in glycerine were also extended to many foliose and fruticose lichens with similar results; and he concluded that the thalli of lichens are richly provided with means for aeration.

It will be noticed that all of the means for aeration enumerated above are not real canals but loose passages between entangled hyphae, and that most of them are accidental or occasional. We have taken pains to confirm Zukal's observations upon the air content of dry sections in glycerine and find the air bubbles in lines and spots. The glycerine treatment then proves the presence of air in lichen thalli. The occurrence of thin places in cortices, the soralia, the cyphellae, the empty spermagones, the hollow cylinders, the crude canals and other makeshifts are a matter of common knowledge among students of lichen anatomy. But after all this is admitted, we are still not convinced that sufficiently rapid air movements and the means for sufficient aeration of the algal hosts in lichens are present. These hosts have greater need for aeration than the lichen itself, which needs air only for respiration, while the alga could use it also for carbon assimilation. Furthermore, the air enters through openings in the tissues of the lichen, which is reached directly, while many of the algal host cells are reached only by a slow circuitous route downward or upward through the cortex, thence through or along the hyphae of the medulla. We are of the opinion that nothing but definite air canals, leading directly from the exterior to all the algal groups within the lichen, could accomplish aeration for these algal cells in an efficient manner.

Schneider's results (111), obtained during the time that Zukal was working, add little to those of the latter worker. Schneider observed algae extending almost to the upper surface, in circumscribed areas, in lichen thalli which had thick cortices elsewhere than in these areas. He also saw, in certain lichen thalli, intracellular spaces passing from some of the algal clusters through the cortex and the epidermis to the exterior, taking a circuitous instead of a direct route, and often following almost a horizontal course in the epidermal layer. He found these crude canals closed when the thalli were dry. His statements read quite as convincingly as those of Zukal, but we can not accept the results

as accounting for sufficient aeration of the algal host within the lichen thallus.

Jumelle (70) worked from the physiological point of view instead of the anatomical. His results show that there is an exchange of gases to and from the exterior for lichen thalli and for the algal hosts, both in light and darkness and at low and high temperatures. But he failed to differentiate between the work of the lichen and its host, and his results seem more uncertain than those of Zukal and Schneider, who worked from the anatomical point of view. Jumelle thought that, instead of the thallus taking part in the process as a whole, there must be special contrivances for aeration. But he did not attempt to prove this, and the results of others seem insufficient.

According to more recent ideas of parasitism of the lichen upon the alga and the ability of the latter to receive nourishment from organic compounds brought up from the substratum by the former, the alga can get along without special provision for its aeration, but would doubtless thrive better were aeration abundant. In fact, it does not appear that lichen evolution has made any special provision for aeration of the algal host as would be required by the mutualism hypothesis. It seems rather that the lichen has developed in a manner best adapted to its own advantage, and that the alga suffers more or less from lack of sufficient aeration, unless it chances to be a species that can secure carbon from the substratum through the lichen quite as well as from the air.

THE RELATION OF THE LICHEN TO ITS ALGAL HOST

Some algal hosts, as *Nostoc, Sirosiphon, Trentepohlia, Scytonema* and *Phyllactidium,* are in contact with the substratum, from which they take food directly; but the conditions of parasitism of most lichens upon the algae are such that the algal hosts become completely surrounded by the parasitic lichen and raised from the substratum. It is this peculiar condition of parasitism, in which the unicellular or the filamentous host is surrounded by the parasite, instead of the parasite being surrounded by the host, or covering only a portion of its surface, as we find in the more usual conditions of parasitism, that has led to the erroneous views re-

garding the relation of the lichen parasite to its algal host. Thus it comes about that many botanists have thought the relation to be mutualistic, some even going so far as to suppose that the host and the parasite together constitute an individual, working in harmony much like the parts of an ordinary automaton. But the facts do not favor this supposition. The host is placed in a disadvantageous position regarding food supply, and then more or less of its food is probably carried to it from the substratum with which it would be in direct contact, were it not for being parasitized by the lichen, which imprisons it and removes it from the substratum. We see nothing in this, on the whole, but disadvantage to the algal host, which could secure its food more easily, were it not parasitized.

Arnoldia and *Physma* are the only lichen genera parasitic on *Nostoc,* which send haustoria into the cells of this algal host, or even come into close enough relation with these cells to effect any change in their form or that of the filaments which they compose. Otherwise, the cells or the filaments of the algal hosts of lichens are more or less modified by the parasitism. Yet one may find, commonly enough, algal cells or filaments not yet parasitized, which show the normal form for the species. In the case of *Nostoc,* where the cells are not usually affected, the whole colony is nevertheless modified in form by the parasitic lichen, as is illustrated by species of the Collemaceae.

Bonnier (31) germinated spores of *Physcia apiolia* (Ach.) Nyl. on the protonemata of mosses and found that the hyphae invest the protonemata, form a plectenchyma and haustoria and sap the protonemata of nourishment. Those on which the lichens grow are smaller than those not parasitized, and are often killed outright, though the haustoria do not penetrate into the cells of the protonemata. He found also that the same often occurs in *Cladonia pyxidata* (L.) Hoffm., when the spores germinate on protonemata and grow as above explained. Sometimes algae fall upon the lichen growing on the protonemata, when the algae become parasitized, and the lichen finally reaches its full development. This indicates that the relation of the lichen to the alga is parasitism, as is its relation to the moss protonemata; but the algae are not so easily killed, and the lichen develops fully when it grows with them.

Nylander once thought that the algae were always free from the lichen hyphae, but later he abandoned this erroneous view. Schwendener (119) made the lichen a parasite and the alga a slave and preceded Warming in applying the term "helotism." He decided that the algae are seized, held firmly by the lichens and become so modified as to be identified with great difficulty if at all. Even such a filamentous alga as *Sirosiphon* parasitized by *Polychidium muscicolum* (Sw.) Gray, and *Rivularia* parasitized by species of *Lichina,* he proved to have the filaments broken up into groups of algae scarcely recognizable as belonging to these genera. He found *Scytonema* so modified, when parasitized by lichens, that he could not decide certainly whether it belonged to the Scytonemaceae or the Rivulariaceae. Much less did he claim any knowledge of the genus or the species. One can distinguish between *Rivularia* and *Scytonema* parasitized by lichens if the apices are normal, but this is very rarely, if ever, the case. Schwendener, in some instances, reached a conclusion regarding the species of the algal host by finding the free algae growing in proximity with the parasitized forms, or was able to distinguish the algae in very young lichens growing in groups of older lichens, which in turn were growing among the free algae. He records finding the algal host of *Pannaria brunnea* (Schw.) Mass., occurring in unrecognizable conditions in convoluted masses. These unroll, when boiled a moment in water or heated in dilute acid, into filaments of 100 or more cells, which belong to *Polycoccus punctiformis* or some closely related *Nostoc.*

The constancy of the dependence of the lichen upon the algal host has been much magnified by those who hold to the theories of mutualism or individualism. Frank was first (57) to note the long duration of growth of certain lichens independently of the host. His first statement was regarding the common *Arthonia radiata* (Pers.) Ach., which he found growing on bark a year or more without the alga, often remaining outside the parasitic relation until the apothecia were fully developed and the spores were forming in the asci. Then the algal filaments appear within the thalli, at first in small numbers, but soon become abundant. Again, Frank (58) records finding *Arthonia radiata* (Pers.) Ach. in its natural habitat, grown to large size without attacking *Trente-*

pohlia, the alga being parasitized later. The algal host enters the thalli from without. Then the thallus grows more luxuriantly and sometimes becomes partly epiphloeodal, though entirely hypophloeodal before parasitizing the alga. The lichen hyphae attack the *Trentepohlia* alga filaments, render them unrecognizable by breaking them up into shorter filaments or into single cells, and then according to Frank, bore into the cell contents of the individual cells. Whenever colonization fails, no apothecia are formed, the lichen (?) dying without fructifying. Frank found assentially the same condition in our common *Graphis scripta* (L.) Ach., which sometimes grows for a time outside the parasitic relation. He also found that *Arthonia dispersa* (Lam. & DC.) Dub. *A. punctiformis* Ach., *Arthopyrenia cerasi* Koerb. and *A. rhyponta* Mass. never enter into the parasitic relation with algae, the technique used showing no algae growing with any of these so-called lichens at any time. Frank studied only a few of the many similar lichens, and such tardy entrance of many of these plants upon the parasitic relation or entire failure to enter into this relation can scarcely be so rare as is claimed by those who adhere to the mutualism theory or some modification of it. These lichens and lichenoid plants are by no means rare and must be dealt with in any consideration of the relation of the lichen to its algal host. Frank found that the cells of the *Trentepohlia* filaments, when parasitized, show much thinner walls than when not parasitized, while the chlorophyll is absent or poorly developed. The oil globules are absent or of a golden or orange red color, while they are an intense rust red color in the free algae. He decided that the algal filaments bore through intact periderm as well as enter through cracks, and that these entering filaments arise from zoöspores which come to rest and germinate on the surface. He thought that the alga bored into the periderm only over lichen thalli; but this can hardly be true since *Trentepohlia* filaments commonly occur in the periderm where no lichens are growing. He observed that the alga resumes its usual form soon after the death of the lichen parasite.

Lindau (81) found that the points of contact between the hyphae of hypophloeodal lichens and the *Trentepohlia* filaments are comparatively few, and that no haustoria are formed. So

he thinks that the relation of these lichens to their algal hosts is a very loose one. In the fruticose *Roccellas,* the *Trentepohlia* cells are rent asunder and attacked by haustoria as are the usual palmelloid host cells in most higher lichens, but not so among the lower lichen parasites. It will be noted that Lindau does not agree with Frank regarding attachment of the hypophloeodal lichens to the algal host cells.

Frank found *Lecanora pallida* Schreb. to be of hypophloeodal origin, and to become epiphloeodal later. The unicellular algal host cells are always present over the central, thicker portions of the thalli. There is a marginal zone of hyphae, from which algal cells are absent. The algae occur singly and much scattered just inside of this zone, though tetrads may be recognized occasionally where the lichen hyphae have not pushed between the cells. These algal cells are, in part, pushed forward by the growing lichen hyphae and form new tetrads; the process is continued, and the host cells thus follow the growth of the lichen thallus laterally. Some of the algae are colorless, but are alive and divide actively. These colorless cells occur among normal green ones, but are absent from some thalli. Continued growth of the lichen and its algal host causes a breaking down of the periderm above, and lichen and host become epiphloeodal, except the marginal zone of the lichen, which remains hypophloeodal. After becoming epiphloeodal, the thallus acquires a pseudocortex of entangled hyphae, and the algal cells come to lie in groups below this cortex. Frank always found one or more cracks in the periderm of the area occupied by the young thalli. Through these he supposed that both the lichen and the algal host enter. He always found the algal cells in the cracks in the periderm. These are present and are attacked by the hyphae as they enter the cracks.

We may now pass to a consideration of some ideas regarding the physiological relations of the lichen to its algal host. De Bary (16) thought the lichen should be regarded the host and the alga a guest, treated with such great consideration that the relation should be regarded mutually beneficial. Reinke (65, 104 and 105) holds practically the same view and uses to express it the term "consortium," proposed by Grisebach (65). Schneider (109) also uses the term "mutualism" to express the relation of the lichen to

its algal host. Warming (140) uses Schwendener's term, "helotism," to express this relation. He believes that the alga grows and reproduces rapidly in the lichen through hypertrophy, a pathologic condition, and that it is hindered from zoöspore formation. Lindau (81) thinks that the lichen is parasitic on the alga, and that the many dead algal host cells result from lack of air and from the absorption of food by the lichen hyphae. Schneider's most extended statement (111) is to the effect that "in individualism is reached the acme of mutualistic association." He then proceeds to tell us that individualism requires that one of the symbionts shall be absolutely dependent upon the other, a condition which he thinks is found in lichens. He admits that the algal host may live without the lichen parasite, but thinks that since the lichen can not get on alone, it and the algal host together form a new physiological and morphological individual. He thinks that at some future time neither symbiont will be able to live alone, and that individualism will then have reached its acme. What fungus can get on well without its host? And what evidence have we, while the alga continues to thrive better alone than when parasitized, and while lichens are commonly found growing near the algae which they parasitize from time to time, that the algal host will one day be unable to live without the fungal parasite?

It is time to be done with these unproved and hopeless hypotheses of mutualism, consortism and individualism and turn to something more promising. In spite of all these hypotheses, the lichen is still parasitic, or more likely partly parasitic and partly saprophytic, on the alga. Those algal cells which are not invested or penetrated by lichen hyphae are usually of normal size and form and are darker green than those in the same thalli that are invested or penetrated by the hyphae. The lichen haustoria surely take from the algae foods which these algae have elaborated for their own nourishment. This must injure the algal host cells seriously and often kill them, for many of the algal cells in lichens are dead and devoid of protoplasm. The bright green cells which one finds in lichen thalli are those algal cells which have recently resulted from division. They are not yet parasitized, or have been parasitized but a short time. The results are the same

whether the hyphae enter the algal cells or not; but the injury to the host cells probably goes on more slowly in the latter case.

Peirce (98, 99) has decided in favor of parasitism of the lichen upon the alga, but inconsistently holds that the lichen and its host somehow form a dual organism in spite of this antagonistic relation. He found that while the algal host cells often multiply rapidly in lichen thalli, they increase yet more rapidly outside the lichens. During wet weather the alga grows more rapidly than the lichen; but during dry weather the lichen grows more rapidly than the alga. In this manner the algal host cells are preserved from complete extermination by the lichen parasite, though some host cells are constantly being killed. In parasitism on multicellular organisms, portions of the hosts are likewise often killed while new portions are being produced by growth. The cells of the unicellular or filamentous lichen hosts separate as they are formed, or constitute short filaments. The isolated cells or the filaments are not so able to overcome the harmful effects of parasitism as are the aggregates of cells in multicellular hosts, in which food supply may pass from cell to cell so that the cells on which the parasite feeds may be nourished from surrounding cells. But the algal hosts of lichens are by no means the only ones that are killed by parasites; nor are they the only ones in which the fungus kills only a portion of the host cells. Water, mineral salts, and probably some organic matter are carried to the imprisoned host. The parasite is not supposed to elaborate this material, more probably acting only as a carrier of food. Another peculiarity of the parasitism of lichens upon algae is that the algal hosts are usually surrounded completely by the parasite. Moreover, the lichen is usually parasitic on a large number of individuals instead of a single one.

Peirce says in his text-book of plant physiology (100) that "because of the small size of the alga, the always larger fungus can not become entirely enclosed in it; on the contrary, the fungus surrounds the alga with a more or less firm mycelium, containing the alga between the parts of its body. The association of the fungus and alga, always intimate enough for the fungus to supply itself osmotically with non-nitrogenous foods elaborated by the alga, is in many cases so exhausting to the alga that many of its

cells become entirely emptied. In spite of this evidence of complete parasitism of the fungus, some botanists claim that the alga is benefited also." We believe that this statement portrays fairly well the relation of the lichen to its algal host.

Elenkin has accomplished some very illuminating work regarding the parasitism or the saprophytism of lichens. He found (48) hyphae of *Lecidea atrobrunnea* (DC.) Schaer. piercing into the algal cells in most instances after the cells were disorganized and empty, but rarely into uninjured cells. He observed a similar relation between *Haematomma ventosum* (L.) Stein. and its algal host and felt uncertain about the rôle of the distorted hyphae found within the algal cells. He thought that the hyphae brought about probably through an enzyme, the destruction of the cell contents and finally of the walls of the algae for nourishment. Whether the lichen hyphae penetrate into the algal cells or work from the outside of the cell wall, he regards this method of nourishment endosaprophytism, since he thinks the role of the hyphae is to absorb dead rather than living matter. His second paper (49) enlarges on the first by treatment of a new series of lichens, but seems to add nothing otherwise. In a third paper (50) he states that his hypothesis is supported by the great abundance of dead algal cells in lichen thalli. He found that in thin sections stained carefully, the dead algae often exceed the living in numbers. He admits that death may be due to parasitism of the lichen on the alga, or to lack of air and light. In favor of the enzyme and endosaprophytism hypothesis he thinks is the presence of dead algae in greatest proportion in the haustorial zone, in which most of the algae occur. Here the lichen hyphae form a compact layer about the algae, so that the enzyme could easily deform and destroy the cells, which would then assume irregular shapes, while their protoplasts would become pale and disappear. Similar destruction of algae continues in the cortex, until the last vestige of algal protoplasts and walls are consumed, he thinks the latter at least saprophytically. Some algal cells remain rounded until after their protoplasts have disappeared. These are probably the ones that produce daughter cells vegetatively. Empty, dead algal cells surpass the living ones only in the haustorial zone of the thallus, while if reproduction ac-

counted wholly for dead cells, the living must here exceed the dead cells in number. So it is reasonable to suppose that the large proportion of dead cells in this region must be due mainly to parasitism or saprophytism. Elenkin thinks more probably the latter, the enzyme killing the algal cells, which are afterward absorbed. The dead cells are not wholly absorbed in the haustorial zone; but they are largely pushed into the cortex by growth, and there their consumption is completed by the lichen hyphae.

This absorption of dead walls, which Elenkin has observed in many lichens, it seems, must be carried on saprophytically, though the contents of the cells are probably consumed parasitically. Of course Elenkin's hypothesis, if true, makes mutualism a little more untenable, if possible, than does pure parasitism of the lichen upon the alga. He studied a wide range of lichen types and various kinds of algal hosts, and concluded that the hyphae, aided by the postulated enzyme, eat into the walls of the algal cells, not so much to obtain the protoplast within as to obtain food from the wall saprophytically. This makes the lichen, at least mainly, a saprophyte, on both the external, organic substratum and the enclosed algal host. Elenkin's hypothesis of endosaprophytism is far from proved, but the lichen is probably partly parasitic and partly saprophytic upon the algal host. Whether the hypothesis is valid or not, its author has placed before us a series of facts regarding the relation of the lichen to its algal host which must provoke much careful investigation and has added materially to a solution of the problems involved.

Danilov (46) found that a hypha enters the algal protoplast, and branches into a delicate network of slender hyphae, which penetrate through the protoplast in various directions. The walls of the hyphae of this network are very thin and can be seen only with great difficulty. One also finds in the algal cells hyphae like those of other portions of the lichen. These occur alone, or with the slender hyphae, one or both kinds filling the entire space within the cell. Danilov thinks that the slender hyphae pass into the ordinary kind, after absorbing the contents of the cell, grow out of the protoplast and attack other algal cells in similar fashion. Through the effects of the slender branched hyphae, the algal cells are deformed and finally killed. He often found the protoplast

shriveled and irregular in form, gradually disappearing and replaced by the larger hyphae. During this process, the algal cells become pale, and many empty cell walls also remain. In an early stage of parasitism of a hypha on an algal cell, when the hypha has just become appressed and enlarged, the algal cell is irritated and divides rapidly, forming new cells, which are free for a time. These are later attacked by the lichen hyphae. Danilov makes nothing of Elenkin's theory of endosaprophytism, but thinks rather that the lichen is purely parasitic on the alga. Of course the relation is wholly antagonistic in either case.

Treboux (134) in a more recent research thinks it hardly supposable that the lichen receives any considerable portion of its organic material from the algal host, or that the alga depends upon the lichen to any appreciable extent, even for carrying water, mineral salts or organic food from the substratum. He thinks it much more probable that the alga obtains both moisture and nourishment mainly from the air. He mentions Beijerinck's work on algae supposed to obtain carbon from peptone compounds and states that *Cystococcus humicola* belongs here and is the host of many lichens. He thinks there are really no peptone algae but rather that most algae can get their carbon from peptone compounds under certain conditions, and from the air under other conditions. So an alga may have one source of carbon when serving as the host for a lichen and a very different one when free, and the lichen may lay hold of free *Cystococcus humicola,* which will at once change its method of nutrition. If this be true, it is no longer necessary that we should think the method of nutrition changed through long living with a lichen. After comparing the *Cystococcus* forming lichen hosts with other algae, he concludes that it is an independent species, distinct from both *Chlorococcum* and *Pleurococcus.* Neither the free *Cystococcus* nor specimens recently isolated from lichen thalli is much given to zoöspore formation. The free-living *Cystococcus humicola* shows the same characters as the lichen host, except for modifications caused by parasitism, and quickly assumes the usual form and method of nutrition when freed. Both the free algae and those recently liberated from lichen thalli readily pass into the hostal relation with lichens in cultures. The alga grows and reproduces much more

rapidly in free nature than in lichen thalli, where it shows a sickly, unnatural appearance, seen in the paler color, the less refractive condition of cell contents, and the common absence of the pyrenoids, all of which indicate parasitism of the lichen upon the imprisoned alga. The injurious effects of the lichen upon the algal host are greatly lessened, he finds, when the lichen and its host are grown together on a favorable nutrient medium, where the lichen can secure more of its nourishment from the substratum, and so depend less upon the host. Treboux's conclusions, though based upon rather limited investigation, seem reasonable, are in accord with other recent results and demand a modification of some views commonly held concerning the relation of the lichen to its algal host. For instance, the lichen may at any time readily lay hold of free algae, an entirely reasonable supposition, which deals a death blow to certain untenable suppositions regarding the nature of lichens. According to his view also the food relation of the lichen to its algal host is not a very close one; but his results at this point are not based on careful investigation, and we are still disposed to believe that higher lichens depend largely upon their hosts for food. Whether *Cystococcus humicola* is distinct from *Chlorococcum* is a problem very difficult of solution, and judgment may well be reserved, especially as this question scarcely affects any important matters concerning the relation of the lichen to its algal host.

C. E. Bessey (22) says in "The Essentials of Botany," "The plant body of a lichen is composed of jointed, branching, colorless filaments similar to those in the other families of this order, but more or less compacted together into a thallus or branching stem. They obtain their nourishment from little green protophytes or phycophytes to which the filaments attach themselves parasitically. These little hosts, which live in the midst of the moist tissues of the lichens, were until recently supposed to be parts of the lichen itself. . . . There is thus an association between these plants which is mutually beneficial (symbiosis). The lichen lives parasitically upon the green plants, to which it in turn furnishes shelter and moisture." Clements in his text (36) defines thus: "The type of parasitism in which the presence of the parasite benefits the host plants in some measure is commonly distinguished as sym-

biosis or mutualism." The views of Bessey and Clements seem identical, though couched in somewhat different terms. Clements' definitions of parasitism and symbiosis, like Bessey's statement, are unusual, but both admit of the use of the term, parasitism, in designating the relation of the lichen to its algal host, even by those who believe in mutualism of the extreme form known as individualism. But parasitism and mutualism, as usually defined, can not be said to exist at the same time between two plants in symbiotic relation. The symbiotic relation must be antagonistic, as in parasitism, or mutualistic, as in mutualism. We admit that the algal host may be benefited in some ways by the association with the lichen; but since the injury received is, as a whole, greater than the possible benefit, the relation is parasitism, or antagonistic symbiosis.

THE RELATION OF THE LICHEN TO THE SUBSTRATUM

Some lichens grow on certain kinds of rocks and others on other rocks; some on barks of certain trees and others on barks of other trees; some on decorticate wood still intact and others on rotten wood; and some on one kind of soil and others on other kinds. Hence, it is reasonable to suppose that lichens secure some nourishment from their substrata rather than to think that their distribution upon various substrata is governed entirely by physical structure of these substrata. Moreover, we can not understand the relation of the lichen to its algal host without considering the relation to the substratum; hence, a summary of knowledge upon this subject must be given in this paper.

Schwendener (117) in his epoch-making studies of the thalli of lichens paid little attention to the lichen rhizoids, but reached the general conclusion that they do not, in higher lichens, penetrate into the periderm to any considerable extent. Lotsy (84) studied the rhizoids of a number of foliose lichens and found them spread out on the substratum; he thought none of them penetrated below the surface. Frank (58) and Bonnier (31) decided that lichen hyphae and *Trentepohlia* filaments are able to penetrate into periderm cells and extract food from the walls and the cell contents. Lindau (81) found that these earlier workers were mistaken, and that the algae, and the lichen hyphae of hypophloeodal lichens,

only pass between the periderm cells, which they often force apart, but never enter. As the periderm layers are forced apart by the lichen hyphae and the accompanying algal filaments, they come to lie in irregular, isolated masses, with large areas of lichen and algal host tissues lying between. Both lichen and alga enter the bark through microscopic cracks and spread laterally in the periderm, the lichen preceding and the alga following and helping to fill the spaces produced by pushing the periderm layers apart. All ascomycetes found in periderm work in the same manner, and one can scarcely study sections of any bark of considerable age, without finding hyphae pushing between periderm layers, sometimes reaching as deep as the fortieth layer.

Cooke (39) found that cinchona bark, when it supports luxuriant growths of lichens, abounds in the medicinal alkaloids characteristic of this tree, while these substances are largely destroyed by other fungi, which may thrive in or on the bark. This would indicate that lichens secure little nourishment from the substratum. Even if Cook's findings are reliable for epiphloeodal lichens, they can scarcely be true for hypophloeodal lichens, which are loosely combined with their algal hosts, some of them living for years in the periderm before attacking an algal host.

It is certain that hypophloeodal lichens which live in the periderm for a year or more outside the relation with an algal host must take nourishment from the periderm, though they do not dissolve sufficient material from the periderm walls to be detected by microscopic examination. So we must believe that these plants secure nourishment from the periderm without entering the cells or producing appreciable diminution in walls or other effects that can be detected without chemical analysis.

The rhizoids of our common *Buellia parasema* (Ach.) Koerb. and our *Rinodina sophodes* (Ach.) Koerb., both epiphloeodal crustose lichens, penetrate through openings to a depth of five or six layers of periderm and spread out between these layers. Lindau (81) found that such foliose lichens as *Parmelia physodes* (L.) Ach. and *Physcia stellaris* (L.) Nyl. surround and penetrate into all elevations of the periderm and also fill the depressions closely. They are often confined wholly to these surface elevations and depressions, but sometimes penetrate between the

outer, loose layers of periderm. They never bore between firm layers of periderm as do the crustose epiphloeodal and the hypophloeodal lichens.

Evernia prunastri (L.) Ach. is attached to the substratum by a broad, basal holdfast, which becomes larger as the lichen grows. Lindau (81) found the plant often attached to lenticels, through whose loose tissues the rhizoids penetrate and also extend a short distance into the surrounding periderm. When this plant grows on older branches, the holdfast penetrates into the periderm and spreads about between the layers, which are finally separated so that masses of hyphae come to lie between them. The rhizoids may penetrate at least to the tenth layer of periderm. The separated layers become thinner as they are pushed outward by the penetrating hyphae, until they are finally only about half their original thickness. The thinning does not indicate that the hyphae have dissolved material in the walls of periderm cells, for if this were true, the hyphae would be able to penetrate through the cell walls. As the periderm layers are carried upward, they come in contact with the atmosphere, which doubtless dissolves the walls. However, it is reasonable to suppose that the air produces some change in the composition of the periderm fragments such that the lichen hyphae may be able to dissolve and appropriate the transformed product, thus securing food and aiding in the thinning process. Lindau observed the same thinning of periderm fragments in which some crustose lichens were growing.

Hypophloeodal lichens, especially those that live a long time outside the relationship with an algal host, must secure a large amount of nourishment from the periderm, with which their whole thalli come in contact. The epiphloeodal crustose species are in closer contact with their algal hosts and less closely attached to the bark. Hence, they must secure more nourishment from the alga and less from the substratum. The foliose lichens enclose numerous algal host cells and are much less closely attached to the substratum than any crustose forms, being above it, while their rhizoids penetrate but a short distance into it, so these must depend still more upon the algal host and less upon the substratum. Fruticose forms are still less closely

attached to the substratum, being fastened usually at one point only, and are, of all lichens, least dependent upon the substratum and most dependent upon the algal host for their nourishment. In general, as the proportion of bulk of the lichen above the substratum increases, the penetration into the periderm decreases, and the lichen becomes more and more dependent upon its algal host. In other words, the lower the lichen, the more dependent upon the substratum and the less dependent upon an algal host; and the higher the lichen in the scale of development, the less the dependence upon the substratum and the greater that upon the algal host. Since the proportion of contact with the substratum decreases as we ascend the scale of lichen development, the higher lichens can hardly carry large amounts of nourishment to the algae within them. The evolution of lichens has involved a gradual change in food supply, and these plants have become more and more dependent upon algal hosts.

The substratic relation of lichens growing on decorticate wood are much like those of epiphloeodal forms on bark, whether the lichen be crustose, foliose, or fruticose. Lindau (81) investigated *Biatorina synthea* (Ach.) Mass. on decorticate pine wood. The thallus and the algal host lie among the tracheids, which become corroded and sloughed off, while the algal cells lie in the cavities thus formed. The lichen hyphae penetrate between the tracheids and push them apart. Then the alga enters, and one finds in section a mass of tracheid fragments, lichen hyphae and algal cells, all of which are sloughed off above as the lichen and the alga penetrate deeper into the wood. The lichen hyphae pass into the tracheids and medullary ray cells, through broken down bordered pits and thus bore deeper and deeper into the wood.

Psora ostreata Hoffm. sends its rhizoids through holes into the rotten pine wood on which it grows, and the hyphae enter the tracheids through broken down bordered pits. They pass from tracheid to tracheid, and penetrate into medullary-ray cells through similar pits, thence deeper into the wood. Both tracheids and ray cells are often filled with rhizoids. *Cladonias* on top of stumps of coniferous trees easily send their rhizoids to unusual depths, entering the cut ends of tracheids, thence passing from

one tracheid to another through the broken-down bordered pits and thus deeper and deeper into the wood.

The substratic relation of lichens that grow on the epidermis of twigs or leaves are peculiar and indicate a very limited dependence, if any, upon the substratum. This points to a pronounced dependence of the lichen upon the algal host. Lindau (81) examined *Biatorina bouteillii* (Desm.) Lind. on the upper surface of fir leaves, where the plant forms a continuous layer. The lichen can be removed easily, since the thallus does not penetrate into the leaves. This agrees well with Ward's (138) results with *Strigula,* which he found growing superficially on tropical leaves, not even attached by haustoria. It may well be doubted whether these lichens receive any nourishment from the leaves on which they grow. It is more probable that they depend wholly upon their algal hosts for food supply. Lindau (81) also studied the foliose *Xanthoria parietina* (L.) Th. Fr. on leaves of *Abies pectinata.* The lichen is closely attached to the leaves by its rhizoids and covers the whole surface. The rhizoids even fill the vestibules of the stomata, but do not enter the tissues of the leaves, which are killed, probably by suffocation. On the bark of the same tree, the rhizoids of this lichen pass through a few layers of the loose periderm. If this lichen can live on leaves without securing food from them, it and other foliose and fruticose lichens should be able to live in the same way on barks.

Fitting (56) decided that certain lichens penetrate into the tissues of leaves and injure or even kill them. He thought that many more might dissolve the cuticle, while a few spread over the surface of the leaf without affecting it in any way. There is no real conflict in this, with the views of Ward and Lindau; for Fitting regarded the alga part of the lichen, and it is the algal host that bores into the leaf before it is attacked by the lichen. The latter is thus brought into a position where it may extract food without itself boring into the leaf, which is often killed where attacked by the algal host, even before the latter is parasitized by the lichen. It is also the alga that dissolves the cuticle, or works its way under this structure and spreads out between it and the epidermis. The *Trentepohlia*-like alga is often seen

living alone under the cuticle. Fitting found that the algal host could bore into some leaves and not into others, so the relation of both alga and lichen to the leaf would vary. Since the leaf is injured only where the alga attacks it and is often irritated into an unusual thickening of epidermis and palisade and a development of suberin at the points affected, it would not be reasonable to ascribe the results to the lichen, which may, however, have a part in working injury where present.

When *Parmelia olivacea* (L.) Ach. grows on small limbs that have not lost their epidermis, the rhizoids branch centripetally below into a hyaline layer of branches, which completely and closely cover the epidermis, but remain wholly superficial. A form of *Physcia stellaris* (L.) Nyl. on the perennial leaves of *Abies pectinata* also forms a complete hyphal layer over the leaf surface, but the rhizoids do not penetrate into the leaf. The lichen is easily separated from the leaf, and the hyphal layers forms a complete negative of the leaf surface. On young branches of the same tree, with epidermis still intact, Lindau (81) found the the leaf and adhered closely to the upper halves of the trichomes that the rhizoids reached only half way down to the surface of the leaf and adhered closely to the upper half of each trichome and to organic and inorganic particles lying between them. If the leaves or the young branches were killed by the lichen, or showed signs of injury, it would seem likely that the closely applied rhizoids might secure food from these surfaces, or from the trichomes. In the absence of such evidence, it appears probable that these lichens do not secure food from the substratum.

Winter (142, 143) seems to have been first to study the relation of lichens to the rocks on which they grow. He found lichen rhizoids penetrating into the rocks to considerable depths and ascertained that the rock can be dissolved with fluoric acid, when the whole rhizoid system appears, and the relation of the lichen to the algal host can be seen plainly. Egeling (47) found that a glass surface on which a lichen was growing became covered with minute cracks, in which were organic and inorganic particles from which the lichen could secure nourishment. Glass is known to be soluble in carbonic acid, and the algal hosts are

probably able to form this substance in the process of carbon assimilation; hence, the surface of the rock would, in time, become corroded so that the lichen hyphae could penetrate into it. Bachmann (12, 13) has since concluded that lichens neither corrode nor penetrate into quartz or silicates; but Stahlecker (125) proved by careful observation that lichen hyphae will penetrate into all rocks, after they have been corroded as explained above.

Zukal (149, 150) studied the sphaeroidal cells and the enlarged hyphae found in lichens on calciferous rocks. By subjecting these structures to careful chemical treatment, he ascertained that they contain a fatty oil similar to that found commonly in fungal spores and sclerotia. He decided that the oil must be a reserve food supply elaborated by the algal host. Fünfstück (63), by removing the algal host and the upper portion of the lichen thallus from the rock, proved that the hyphae still remaining in the rock continue to grow for two or three years without the algal host and produce the sphaeroidal cells and the enlarged oil-bearing hyphae as well as before. He thus proved positively that the algal host plays no part in the oil production, and decided that the oil is not a food but a waste product, of no use to the lichen. He has proved the first point, but not the second.

Bachmann (8, 9, 10) studied the relation of certain lichens to the dolomite and the limestone on which they grow, by dissolving fragments of the rock and by grinding pieces of rock into thin sections, in which the lichen and its algal host cells could be seen. He found that these lichens of calciferous rocks are usually hypolithic, only the fruits showing at the surface. The lichens he found to penetrate from 200 to 12,000 or 14,000 mic. into the rock, while the algal cells reach depths of 100 to 500 mic. Each algal group is surrounded closely by lichen hyphae; but neither Bachmann nor other workers has found out more regarding the relation of the lichen to the algal host in these or other rock-inhabiting lichens. The hyphae eat their way into the rock without respect to structure, passing through crystals of various forms and sizes. In support of the belief that the oil is reserve food, Zukal claimed that lichens that grow on bark, on earth and on rocks devoid of lime or magnesia contain the same kind of fatty oil, sometimes in as great abundance as those that

grow on calciferous rocks. He thought that the oil must be produced with little regard to the amount of lime in the substratum, while Fünfstück, who regarded the oil a waste product, failed to find it in considerable quantity, except in lichens that grow on calciferous rocks. Bachman agrees with Zukal, while Friederich and Stahlecker agree with Fünfstück. Those who regard the oil a reserve food, think that it is most abundant about the time that the lichen fruits begin to form, while Fünfstück found it quite as abundant at other times and in lichens that produce little or no fruit.

Bachmann (11) also worked on the lichens on silicious rocks and found that the rhizoids usually penetrate through the mica particles of granites, commonly passing between the lamellae, but sometimes passing through them. He found the oil-bearing sphaeroidal cells, but performed no careful chemical analyses to prove that lime is not present in some of these rocks in sufficient quantity to account for their presence. As stated above, Bachmann concluded that lichens do not attack quartz and silicates chemically; but it has been proved that they or their algal hosts secrete acids which do corrode these rocks so that the lichen hyphae penetrate into them. It is certain that moisture, oxygen, carbon dioxide and carbonic acid are rather abundant about lichens because of the nutritional processes of the lichens and their algal hosts, and one or more of these agents will dissolve any rock.

Stahlecker (125) subjected rocks to careful chemical analysis and found that ordinary statements about the character of rocks on which lichens grow are very unreliable, and that there is really a close relation between the oil secretion and the amount of lime and magnesia present in the rocks. Friederich (59) ascertained that lichens attack all rocks, but lay hold on the more basic portions sooner than the more acid. This would account for finding certain portions of granites attacked and others left bare for a time, but does not warrant the conclusion of Bachmann that some rocks are not attacked at all.

In general, the more the lichen penetrates into the rocks the less numerous are the algal host cells, and the less the penetration into the rock, the more abundant the algal cells. So the quartz and

silicate inhabiting lichens, which are mainly epilithic, are poorly developed, while their algal host is strongly developed. Lichens that grow in the calciferous rocks are strongly developed, and the algal host cells are not abundant. This favors the view that the more intimate the relation of the lichen to the rock, the less its dependence upon an algal host. This again favors the conclusion that the oil is a reserve product and accords with our finding that, in bark-dwelling lichens, the closer the relation to the substratum the less intimate that with the algal host. Fünfstück (63) found that the more abundant the algal host cells, the less the amount of oil present; and this, with his other findings given above, makes our conclusion practically certain.

It may seem that we have gone far afield in discussing at some length the relation of the lichen to its algal host and to the substratum. For the writer and some others, this would not have been necessary in the present series of papers, for some of us believe that the lichen is a fungus, whatever its relation to the algal host. But for others, the traditions would not be abandoned without proving that the lichen is a parasite, or perhaps partly a saprophyte as well, on the alga. As stated above, it will be seen that the relation of the lichen to the algal host can not be understood until we also have before us the facts regarding its relation with various substrata. Hence, we have given a summary of knowledge on these points and are ready to treat, in the next paper, the classification of lichens, with the matter of their nature thoroughly considered.

SUMMARY AND CONCLUSIONS

1. There has been hitherto no agreement regarding the nature of the lichen, and the only thing about the problem generally believed by botanists is that the green and the blue-green cells in lichens are algae.

2. Due probably to clinging to traditional phraseology, most botanists are not able to express themselves consistently with respect to any view that they may hold relative to the nature and the proper treatment of lichens.

3. The text-book statements about lichens are rarely coherent, excepting those that cling to an entirely traditional and erroneous position.

4. The fundamental problem concerns the nature of lichens, and this must be settled before we can hope to agree regarding the classification of these plants.

5. Due to peculiar ideas about the relation of the lichen to its algal host, this problem of relationship has become the main part of the consideration of the nature of the lichen. It is therefore treated at length in this paper.

6. Recent researches prove that all hypotheses of mutualism between the lichen and the symbiotic alga are erroneous, and that the lichen is a fungus pure and simple.

7. The following are the main arguments against mutualism. Lichens commonly grow where there are free algae of the same species as those parasitized by these lichens. The spores of the lichens germinate and attack the free algae as other fungi attack their hosts. Lichens perform like other fungi on culture media and may be made to produce their reproductive organs on these media. Their development on such media does not differ from that reached when growing with their algal hosts more than other fungi vary from their usual appearance when grown on culture media. Lichen spores also attack the algal hosts, when the spores and the algae are introduced into cultures together; and the resulting lichen is normal and sometimes fructifies in the cultures. Algal hosts extracted from lichen thalli grow in cultures like free algae of the same species grow on similar culture media. Some lichens live for years in their substrata outside the relation with their algal hosts. The researches of Elenkin and Danilov prove that lichen hyphae absorb food from the algal host cells, which are killed by severe parasitism or more probably by parasitism and saprophytism combined. The relation of the lichen to its substratum proves that higher lichens can take comparatively little food from it and must depend more than lower lichens upon the algal hosts; and this shows that the parasitism of the lichen upon the algal host has become more severe in the evolution of higher lichens. Finally, the algae parasitized by lichens are in a disadvantageous position with reference to carbon assimilation.

8. The following are the main arguments for the fungal nature of lichens. Lichens are like other fungi with respect to vegetative

structure and fruiting bodies. The bridges which connect lichens with other fungi are not few but many. Since it is thoroughly demonstrated that the lichen is parasitic, or partly parasitic and partly saprophytic on the alga, there is no longer even a poor excuse for a "consortium" or an "individualism" hypothesis.

9. The parasitism of lichens on algae is peculiar in that the unicellular or the filamentous hosts are usually enclosed by the parasite, which may carry more or less food material to its host. The host inside of the parasite is placed in a disadvantageous position with reference to carbon assimilation and may depend, for its carbon supply, more or less upon material brought from the substratum by the parasite. Some algal individuals not yet parasitized may be found in most lichen thalli.

10. *The lichen is a fungus which lives during all or part of its life in parasitic relation with the algal host and also sustains a relation with an organic or an inorganic substratum.* The definition may need modification later to recognize Elenkin's hypothesis, in part or fully.

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THE PROBABLE IDENTITY OF STROPHARIA EPIMYCES (PECK) ATK. WITH PILOSACE ALGERIENSIS FRIES

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While making notes on the species of *Stropharia* reported from this country to accompany some photographs soon to appear in the *Transactions of the Wisconsin Academy of Sciences,* my attention was called by my brother, Prof. R. A. Harper, to the fact that Lanzi's figures of *Pilosace algeriensis* Quél. (Fungi Mang. *pl. 67. f. 3*) closely resemble *Panaeolus epimyces* Pk. or *Stropharia coprinophila* Atk. The drawings by Miss Helen Sherman (Jour. Myc. 11: *pl. 80*) and the photographs by Prof. Atkinson (Plant World, June, 1907) show a striking resemblance to Lanzi's figures and a comparison of the published descriptions confirms the evidence of close relationship between the European and American plants. The size and shape of both plants is the same, pileus 1–2 inches broad, stem 1–2 inches long, up to ½ inch thick. The stem of the European plant is solid or stuffed, that of the American plant is the same, becoming hollow when old. The pileus and stem in both plants are whitish and silky. Both have purplish-brown or blackish spores. Peck gives the measurements 5–6 × 7.5–9 μ. Miss Sherman says the spores are slightly larger, up to 7 × 10 μ. Atkinson gives the measurements 3.5–4.5 × 7–8 μ; Lanzi 5.5 × 6.5–7 μ, and describes them as inequilateral or slightly reniform. Quélet reported the spores as subsphaeroid, 8 μ in diameter. The greatest difference appears to be in the reports as to the attachment of the gills. Lanzi says the gills are distant from the stem and free. Peck described them as rounded-adnexed. Atkinson says the gills are adnate to adnexed, slightly sinuate or rounded, and he places the plant in the genus *Stropharia,* but reports the stem as separating easily from the pileus, which is a character of plants with free gills.

The comparison proves the very close relationship of the two

plants. The differences are no greater than might be expected in plants from such widely separated localities. In some characters, such as spore measurements, Peck and Lanzi agree better than Peck and Atkinson. Lanzi does not describe his plant as a parasite nor recognize the "tuberous mass" at the base of the stipe as an abortive host. His figures, however, leave no question as to the identity of the parts in the two forms. His interpretation of the cleft which appears in the vertical section of the basal bulb is erroneous. Such a cleft could not possibly have anything to do with the formation of a ring and it has been recognized by the American students of the material with entire unanimity as representing the gill cavity of the host. In the Madison material, rudimentary gills and ripe spores of the *Coprinus* are found in this cleft. Lanzi also misinterprets his figure *c*, which must have been based on a mature stage of the plant with a very short stipe. Lanzi regards the fungus as rare and apparently neither he nor Quélet ever collected it personally.

The American plant was first described as *Panaeolus epimyces* Peck (Rep. N. Y. State Mus. **35**: 133–134). Dr. Peck left the host plant undetermined. Atkinson described the same plant independently, naming it *Stropharia coprinophila,* and determined the host plant as *Coprinus atramentarius* (Jour. Myc. **8**: October, 1902). Mr. F. E. McKenna and Miss Helen Sherman studied the plant at Madison, Wisconsin, and determined the host plants as *Coprinus atramentarius* and *Coprinus comatus* (l. c. *107–169.* 1905). Prof. Atkinson has written a second paper on the plant in which he admits the identity of his plant with *Panaeolus epimyces* of Peck, but holds that it is a *Stropharia* and names it *Stropharia epimyces* (Peck) Atk.

The European and American forms certainly belong to a single group, including *Pilosace algeriensis* (Fries) Quél. (Fl. Jura Vosg. 351), *Panaeolus epimyces* Peck, and *Stropharia coprinophila* Atk. The common method followed by Atkinson when he made the combination *Stropharia epimyces* (Peck) Atk. results in the burying of much information about it. Atkinson wrote a new description of the plant and when this is compiled in the *Sylloge* or a manual the student cannot know that other spore measurements than $3.5–4.5 \times 7–8\,\mu$ have been observed; that the gills

have been found simply adnexed instead of adnate to adnexed, etc. The collector of plants like those found by Peck or Miss Sherman, who attempts to use Atkinson's description, will find himself in a predicament understood by everyone who has attempted to identify agarics from descriptions.

An interesting result of Lanzi's work in making *Pilosace algeriensis* known in Europe is that Cooke's illustration of that species in his plate 618 is shown to rest on an incorrect determination. The figure has been copied far and wide as an illustration of the genus. Lanzi suggests that it may be based on an exannulate form of *Agaricus campestris* such as that figured in Cooke's plate 528.

GENESEO, ILLINOIS.

NEWS, NOTES, AND REVIEWS

Dr. B. T. Galloway, chief of the Bureau of Plant Industry since 1900, has been appointed Assistant Secretary of Agriculture by President Wilson, and Dr. W. A. Taylor succeeds him as chief of the Bureau.

Mr. Stewart H. Burnham, for some years assistant to the state botanist at Albany, resigned on April 1 on account of ill health. His address is now Hudson Falls, New York.

Dr. E. A. Burt, professor of natural history in Middlebury College, Middlebury, Vt., has been appointed librarian and mycologist of the Missouri Botanical Garden. The appointment will date from next September.

Professor L. H. Pennington, of Syracuse University, and Dr. Gertrude S. Burlingham spent the Easter holidays at the Garden consulting the mycological herbarium and library in preparation of manuscript for a forthcoming part of NORTH AMERICAN FLORA.

The first number of *Phytopathology* for the current year contains, in addition to several important contributions, a full account of the Cleveland meeting of the American Phytopathological Society with abstracts of the papers presented. The editors are to be congratulated upon the decided improvement in the general appearance of this periodical.

A valuable collection, containing several hundred specimens of fleshy and woody fungi, has been recently obtained for the Garden herbarium from Femsjo, South Sweden, by Mr. Lars Romell, probably the best Swedish authority on these groups of plants. Specimens from this locality are especially interesting on account

of the studies made there by Elias Fries in the early years of his life.

Shear's Studies of Parasitic Species of Glomerella

"Studies of the fungous Parasites belonging to the genus *Glomerella,*" by Dr. C. L. Shear, appears as Bulletin 252 of the Bureau of Plant Industry of the United States Department of Agriculture. The name *Glomerella* is the generic name applied to the ascogenous stage of *Gloeosporium* or *Colletotrichum,* which attacks various kinds of plants giving rise to a variety of diseases.

The object of the paper as set forth by its author is to determine the life histories, habits and identity or relationship of the forms of *Gloeosporium* or *Colletotrichum* found on the same or different hosts. The paper covers the investigations of members of this group of organisms obtained from 45 host plants. Of the 473 species of *Gloeosporium* and *Colletotrichum* given by Saccardo not including members of the genus included by Saccardo under other generic names, it is estimated by Shear that about 50 per cent. of these so-called species cannot be determined except on the basis of host relations or the part of the host attacked.

The life history of forms from 36 different hosts plants have been determined and recorded in this paper, 17 having been produced in pure culture and 19 on the host either in moist chamber or under natural conditions. All of the material from the 36 hosts is referred to three species, *G. cingulata, G. Gossypii,* and *G. lindemuthianum,* the first occurring on 34 hosts and the remaining two on one host each.

None of the morphological or physiological characters in the genus seem to be well fixed, the conidia, chlamydospores, perithecia, ascospores, and paraphyses showing a wide range of variation. Most forms do not seem to be restricted to any particular host.

The question is raised as to why the life cycle of *Glomerella* and other pyrenomycetes is sometimes completed in pure culture while at other times only conidia or pycnospores or no fructification of any kind is found. Various views on this subject have been summarized but the question is still an open one for *Glom-*

crella although some of the supposed factors have been tested sufficiently to eliminate them.

F. J. SEAVER.

RIDGWAY'S NEW COLOR GUIDE[1]

A new color guide by Dr. Robert Ridgway, the well-known ornithologist, is practically an entirely revised and much enlarged edition of his earlier nomenclature of colors (1886) with 17 plates and 186 colors as against 53 plates and 1,115 colors in the present work. The color work was done by A. Hoen & Co., of Baltimore, and is much more uniform in different copies than in the earlier edition, which was hand stenciled from several mixings of the same color; while in the present work each color for the whole edition of 5,000 copies was prepared from one lot of color and uniformly coated at one time. While the present work does not contain quite as many colors as are included in the more bulky French work by René Oberthur, the gradation between colors is more uniform, and the colors are on dull instead of glossy-surfaced paper as in that work, which gives a slightly different, but more natural color effect, and no metallic color effects are included. The proportion of darker broken colors is greater, which will appeal especially to the ornithologist and mammologist, although the work is designed to be equally useful to botanists, florists, artists, dyers, merchants, and chemists who require a standard color scheme. The colors have evidently been standardized to a degree of accuracy not hitherto attained in any color chart. The colors are one-half by one inch, arranged on a heavy gray paper in three vertical columns of 7 colors each. The plates are divided into 6 series. In plates I–XII the middle row of horizontal colors represents the 36 colors and hues most readily distinguished in the spectrum, although it is said to be possible to distinguish 1,000. Above these colors each succeeding horizontal row of colors is the spectrum color mixed with 9.5; 22.5; and 45 per cent. of white. Below they are mixed with 45; 70.5 and 87.5 per cent. of black. Plates XIII–XXVI represent the colors in

[1] Color Standards and Color Nomenclature. By Robert Ridgway [3447 Oakwood Terrace, N.W.], Washington. Published by the author 1912. Pp. 1–44; pls. I–LIII. $8.00.

plates I–XII dulled by 32 per cent. of neutral gray; plates XXXII–XXXVIII are dulled by 58 per cent. of neutral gray; plates XXXIX–XLIV are dulled by 77 per cent. of neutral gray; plates XLV–L are dulled by 90 per cent. of neutral gray; and plates LI–LIII are dulled by 95.5 per cent. of neutral gray. If the color to be matched is darker than in the first series of plates, turn to the same position in the succeeding 5 series of plates until one is found that is dark enough to match. This is readily done by referring to the numbers at the head of the vertical columns and to the letters at the left of the horizontal rows. In numbering and lettering the rows of colors, every other number and letter has been omitted so that colors that do not exactly match any in the present work, but are intermediate, can be designated by a symbol. For example, in plate I the vertical columns are 1, 3, and 5; the tints b, d, and f; and the shades i, k, and m. All the colors are named as well as symbolized, but if a given color comes between Hermosa Pink (1 f) and Eosine Pink (1 d) it could be designated 1 e. In this manner about 2385 additional colors or a total of 3500 can be designated. Undoubtedly exception will be taken to some of the names, but in this the personal equation plays such a large part that decisions must be rather arbitrarily rendered. The primary colors have been standardized by Dr. P. G. Nutting, of the U. S. Bureau of Standards.

It was originally expected that six months would suffice for the preparation of the colors, but unforeseen difficulties in reproduction have extended this period to about three years.

A list of color synonyms as shown by the immense list of trade samples that must have accumulated would have formed an exceedingly interesting and valuable addition to the work.

A table of percentages of color, together with an explanation of the amount of white, black, or neutral gray used as above, will give an approximately ready clue to the reproduction of any color in the guide, the only uncertain factor being the possible lack of standardized primary colors with which to begin.

Definitions of the principal color terms, such as color, shade, tint, hue, tone, etc., which are used almost interchangeably by many people, will repay careful study by those not familiar with their exact use.

A slight error on page 12, due to a misunderstanding, should be corrected. Mr. F. A. Walpole had no connection with the color project of the American Mycological Society, the preparation of which was delegated to the late Dr. L. M. Underwood, Dr. W. A. Murrill, and the writer. Mr. Walpole died before the committee was appointed, and the project was abandoned after two years' work by the committee in favor of Dr. Ridgway's work, which had not previously come to their notice.

P. L. RICKER.

FAULL'S CYTOLOGY OF THE LABOULBENIALES

Faull[2] has recently published an account of his cytological studies upon two species of the Laboulbeniaceae found on the elytra and on the free tip of the abdomen of the common whirligig beetle. The species, *Laboulbenia chaetophora* and *L. Gyrinidarum,* are closely related forms and are not easily distinguished in the young stages. Both species are apogamous, nothing resembling antheridia being found, although a much-branched multicellular trichogyne is present in each species. Thaxter's account of the general morphology of species of the genus are confirmed in a number of points.

The methods in ordinary use for fixing and imbedding fungi were employed. The septa between the daughters of the same mother cell are single pitted, and a continuous protoplasmic tract extends through the receptacle to the tips of the appendages. No broad protoplasmic bridges, however, are to be found between the cells of the receptacle. The protoplasm which dips into the opposite lying pits is in reality separated by the thin middle lamella which is perforated by one or more minute pores. Only very fine strands, plasmodesmen, connect the cells. The septa in the appendages are apparently coarsely perforated, so that the cytoplasmic fibrils extend out from the pits in the cells of the receptacle, and occasionally similar strands are seen leading out from the nuclei. Their function has not been determined except that

[2] Cytology of the Laboulbeniales, Ann. Bot. 25: 649–654. Jl. 1911: The cytology of *Laboulbenia chaetophora* and *L. Gyrinidarum.* Ann. Bot. **26:** 325–355.

in disintegrating cells they are very persistent elements of the cytoplasm.

The nucleus of the carpogenic cell is succeeded by two nuclei, after which the nucleus of the trichophoric cell migrates down close to the carpogonium and undergoes a homoeotypic division. About the same time the septum between the two cells disappears, leaving a long four-nucleated cell. A restored trichophoric cell is then cut off carrying one of the trichophoric daughter nuclei; an inferior supporting cell with one of the two nuclei which succeeded the carpogenic nucleus is cut off below. Four nuclei now appear in place of the two remaining centrally-placed nuclei, and a superior binucleate supporting cell is formed above, leaving a binucleated ascogonium below. The ascogonium may become an ascogenic cell directly, or a second inferior supporting cell may be cut off from it, and a second ascogenic cell may be formed, each cell being binucleate. At this important point the exact line of descent of the nuclei to be found in this series of binucleate cells was not determined. Whether the nuclei in the ascogenic cells are sister nuclei, a few divisions removed from the nucleus of the carpogonium, or whether they are non-sister nuclei, the great-granddaughters of the trichophoric and carpogenic cells respectively, is not stated. The author would seem to infer that the latter is the case by the statement that the nucleus of the trichophoric cell "joins forces with that of the carpogonium." The nuclei in the ascogenic cell divide conjugately, non-sister nuclei passing up into the ascus which buds off directly from the ascogenic cell. Their fusion follows. Four chromosomes appear at the conjugate divisions in the ascogenic cells and the same number is to be found at each division in the ascus; reduction occurs in synapsis of the first division. A well-marked centrosome is found upon the nuclear membrane. The behavior of the centrosome in nuclear division, and its connection with the chromatin threads seems to be very similar to what Harper describes for the Erysiphaceae. Faull still maintains, however, that the astral rays take no part as such in the delimitation of the spores, but agrees that the centrosome is the center of activity to the extent that the spores are delimited by the differentiation of a limiting layer

of protoplasm that begins adjacent to the centrosome and continues progressively.

Faull has procured additional cytological evidence for placing the Laboulbeniales among the true Ascomycetes. It should be noted, however, that the method of ascogonous formation here described is entirely unlike anything known among the ascomycetes. Although he has heretofore been inclined to view the ascus as having been evolved from the zoosporangium of the Oomycetes, he now admits that there may be some grounds for relating the Ascomycetes to the Florideae. "Such features as a uninucleate antheridium, the possibility of proliferation of spermatia from the same antheridium, and the exogenous types of spermatium organization suggest similar phenomena in the rusts, many Ascomycetes, and in the Florideae."

B. O. DODGE.

MAIRE'S REMARKS ON SOME HYPOCREACEAE

Under the title "Remarques sur quelques Hypocréacées"[3] R. Maire discusses a number of species belonging to the genera *Pyxidiophora, Peckiella, Hypomyces,* and *Nectriopsis,* the last being a new genus. In this paper a number of data are given which add to our knowledge of the North American Hypocreales.

In the "Hypocreales of North America"[4] the writer made *Hypomyces boletinus* Peck a synonym of *Hypomyces chrysospermus* (Bull.) Tul. with a note that the spores in the North American specimens examined were smaller than usually indicated for European specimens. On this difference Maire retains the American form as a variety of the European. At the time this note was made it was the opinion of the writer that the difference in size of the spores was due to immaturity of the plants examined. It still seems likely that this apparent difference would fade out if a careful comparison could be made of a sufficient number of plants from both America and Europe. The species is common on *Boletus* but the conidial phase is more common than the perfect and is identical in the European and

[3] Ann. Myc. 9: 315–326. 1911.
[4] MYCOLOGIA 2: 76. 1910.

American plants. The perithecia develop quite readily in the laboratory.

After a study of cotype material of *Hypomyces hyalinus* (Schw.) Tul. in the herbarium at Paris, Maire agrees with the writer in regard to the spore characters, the species being characterized by the unequally septate, verrucose spores. *Hypomyces inaequalis* Peck is used as a synonym as has been previously done by the writer (l. c.). Maire calls attention to the fact that the species has also been recorded from Europe, a fact which was overlooked in our own monograph.[5]

Hypomyces macrosporus Seaver is made a synonym of *Hypomyces armeniacus* Tul. When this species was described a note was appended stating that the plant was first thought to be *Hypomyces ochraceus* (Pers.) Tul. The absence of material illustrating this species in Persoon's herbarium, together with several apparent differences, led me to describe the species as new. Maire points out that it is identical with *Hypomyces armeniacus* Tul. in the Paris herbarium and adds *Hypomyces ochraceus* (Pers.) Tul. as a doubtful synonym. These observations are important as they clear up the identity of our North American species. The species is characterized by the very large verrucose spores.

Specimens of *Hypomyces tegillum* Berk. & Curt. in the herbarium at Kew show perithecia, but no mature asci were seen. Maire reports that cotype material in the Paris herbarium have asci in good condition, and completes the description of the species. *Hypomyces papyraceus* (Ellis & Holw.) Seaver differs in the much smaller spores.

Nectriopsis is proposed as a new genus, differing from *Byssonectria* in its 2-celled spores. *Hypomyces violaceus* Tul., which was placed in the genus *Byssonectria* by the writer, is included in the new genus. *Hypomyces aureo-nitens* Tul. is also included in the new genus. The American material described under this name in North American Flora is said to differ in its much smaller spores and the absence of the *Penicillium*-type of conidia.

The paper is illustrated with one plate containing careful drawings of the spores of the species discussed, and is a valuable addition to our knowledge of the North American Hypocreales.

F. J. Seaver.

[5] Fries, Summa Veg. Scand. 383. 1849.

WOLLENWEBER'S STUDIES ON THE FUSARIUM PROBLEM

A paper entitled "Studies on the Fusarium Problem," by Dr. H. W. Wollenweber, appears in *Phytopathology* (3: 24–50. 1913). As an introduction to this paper he first discusses "unreliability of the stroma as a taxonomic character" in the ascomycetes. He says in referring to the stroma, "Doubts, however, as to the value of the basis of Fries' system have been frequently expressed." "These doubts have recently been confirmed by careful comparative studies of exsiccati and by pure culture study of ascomycetes and fungi imperfecti." He also says, "This system somewhat modified is still in use." Also, that it will be difficult or almost impossible to follow the proposition to divide the Hypocreales into groups according to the presence or absence of stroma as has been done in NORTH AMERICAN FLORA.

He might have discussed "Unreliability of Any Taxonomic Character" and all of the arguments which have been advanced in support of his ground would apply with equal validity to many if not all of these characters. That the stroma, in certain cases, is variable, has long been recognized by taxonomists, but to argue that divisions should not be made on this character because it is variable *in certain cases* is about as logical as to argue that the animal and plant kingdoms should not be separated because there are certain groups on the border line which at different stages in their life cycle partake of the character of both animal and plant.

If he had said that it is impossible to separate *some* Hypocreales on the presence or absence of stroma, his statement would be more nearly in accord with fact, but to say that the order as a whole cannot be separated on this character is misleading. Before one undertakes to judge as to the value of a character from a taxonomic point of view, he should first take the trouble to look up some of the facts involved. That Dr. Wollenweber did not do this is evident from his own writing, for in referring to the stroma he says, "It may, however, be of taxonomic value in extreme cases when it entirely encloses the perithecia . . . (*Claviceps, Cordyceps, Xylaria*)." If he had had the facts clearly in mind, he would have known that in certain species of both *Xylaria* and *Cordyceps* the perithecia are not immersed but entirely superficial. Again he writes, "Intermediate groups such as the Hypo-

creaceae having free perithecia, or with the latter partly covered by the stroma. . . . " . . . In many of the Hypocreaceae, contrary to his statement, including the genus *Hypocrea* itself and related genera, the perithecia are entirely immersed, in fact are scarcely more than cavities hollowed out of the stroma. In no genus in the whole order is any character more constant and reliable than the stroma in *Hypocrea, Chromocrea, Chromocreopsis, Podostroma* and other related genera. Even in such cases as *Cordyceps,* in which it might appear extreme to one whose knowledge of the genus is limited to one or two species, the stroma is sometimes quite variable. In at least one case, *Cordyceps Cockerellii,* the stroma becomes so changeable and unreliable that it is on the border line between *Cordyceps* and *Ophionectria.* But, as a whole, the genus *Cordyceps* is well defined. If there were no intermediate forms, classification would be no problem.

Again, referring to Maire's work on *Nectriopsis,* he writes, " In pure culture [*Hypomyces*], however, I find apiculi or sharply pointed ends only on young ascospores, with more or less obtuse ends in maturity." The species on which this observation was made is not named. The genus *Hypomyces* was founded by Tulasne (not Plowright) on *Sphaeria Lactifluorum.* This species has been studied by the writer from living material both in the laboratory and field over long stretches of time, involving literally bushels of material and in no case have my observations on the ascospores borne out those of Wollenweber, which leads me to suspect that the peculiar condition observed in his work was due to abnormal conditions or possibly that he did not have a *Hypomyces* at all.

On this latter observation, which is so lacking in detail that it is not conclusive, he rules that the morphology of the ascospore is not a reliable character on which to separate *Hypomyces* and *Nectria.* On even more limited observation he adopts a new character, " true chlamydospores," in which, to use his own words, " we have an excellent differential character between both genera." What reason he has to assume that chlamydospores occur throughout the genus *Hypomyces* and not throughout the genus *Nectria,* since they have been reported in some species of both genera, he does not make clear. If they should later be

found to occur throughout both genera, we cannot understand how their presence or absence could be used as a differential character between the two. If later they should be found to be common to many of the pyrenomycetes, having been already reported in several, we fail to understand how their presence could be of any value as a generic character at all. Then, with our present incomplete knowledge of the nature of, or the conditions under which chlamydospores are formed, what reason have we to believe that they are constant in their occurrence in any given species? Is it not possible that their presence or absence may be even more unreliable than the stroma itself?

On the above outlined uncertain evidence, he adopts the presence or absence of chlamydospores as a differential character between *Nectria* and *Hypomyces* and proposes in order to make the character fit the few species investigated to transpose all the species of *Nectria* in which chlamydospores *have been reported* to the genus *Hypomyces,* and publishes the new combination for *Nectria Ipomoeae* Halsted.

While no line of work is of more value to the taxonomist than life history study of the various species of fungi, yet to attempt to draw general conclusions as to the value of taxonomic characters by an investigation of a few isolated species is not improving classification but only adding chaos to confusion. After thus so easily disposing of most of the difficulties in the classification of the Hypocreales, he then proceeds to record the results of his work on *Fusarium,* in which field he has contributed much valuable knowledge to the cause of science.

The genus *Fusarium* is divided into sections on the basis of the forms of the conidia, as follows: Elegans, Martiella, Discolor, Gibbosum, Roseum, and Ventricosum. The types of conida on which these sections are based are given in an accompanying plate. *Verticillium* is briefly considered, although showing no morphological relationship with *Fusarium. Ramularia,* which differs from *Fusarium* in its cylindrical conidia, is also considered.

It is assumed as a general rule that the presence of chlamydospores in certain sections of *Fusarium* indicates the absence of ascogenous stages. There are, however, exceptions in *Hypomyces* and *Nectria.*

The wilt disease is fully discussed. The view which has been previously advanced that *Neocosmospora* is an obligate saprophyte and not connected with *Fusarium vasinfectum* Atk., as has been supposed, is sustained. The question then arises as to the validity of the name *Neocosmospora vasinfecta* Smith, the species having been founded on Atkinson's name given to the *Fusarium*. This illustrates the difficulty, at the present stage of our knowledge, of relying on conidial characters in the classification of the Ascomycetes.

Considerable space is devoted to "Tuber rot and ring discoloration of the potato." According to his investigations, six species of *Fusarium* have been confused with *Fusarium Solani;* also *Hypomyces Solani* and *Nectria Solani,* which have been thought to represent its ascogenous stage and are now regarded as harmless saprophytes. It is claimed that all of these species of *Fusarium* can be distinguished on morphological characters.

This paper contains many valuable suggestions, but, from the standpoint of a taxonomist, it would seem to me that if more space had been used in recording exact details of pure culture experiments on which these conclusions are based and a little less in generalizing on their probable application, its value would have been greatly enhanced, at least so far as our knowledge of the ascomycetes is concerned.

F. J. Seaver.

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COOKEINA SULCIPES (Berk.) O. Kuntze
COOKEINA TRICHOLOMA (Mont.) O. Kuntze

MYCOLOGIA

VOL. V JULY, 1913 No. 4

SOME TROPICAL CUP-FUNGI

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FRED J. SEAVER

(WITH PLATES 88–90)

The genus *Cookeina* was established by O. Kuntze to take the place of *Trichoscypha* of Saccardo, the latter name being untenable. A month later the genus *Pilocratera* was proposed by P. Hennings for the same reason, apparently without knowledge of Kuntze's work. The name *Pilocratera* was adopted by Lindau in Engler & Prantl's Natürlichen Pflanzenfamilien, but incorrectly so since the name proposed by Kuntze had priority. The genus is most closely allied to *Sarcoscypha* of Saccardo, but the species which are essentially tropical are probably distinct enough to be retained in a separate genus.

As the name implies, the plants are usually hairy and the hairs when present are composed of a fascicle of mycelial threads the whole tapering into a bristle-like apex. In one species, *C. Colensoi*, which is here included with the genus, the hairs are absent and the outside of the cup is clothed with granules consisting of loosely arranged cells. While well-developed hairs are wanting in this species other characters indicate a close relationship with the other members of the genus to which it undoubtedly belongs.

Another character of the genus which deserves especial mention is the peculiar markings of the spores. Three of the four species examined have striate spores. In one species, *C. insititia*, no striations were observed. However, as only one collection of this species has been seen it is possible that a further study of the species will reveal this character. The striations are not in

[MYCOLOGIA for May, 1913 (5: 93–184), was issued May 6, 1913.]

the nature of thickenings or cracks such as those found in some of the Ascobolaceae but are light and dark bands extending from one end of the spore to the other but not roughening its surface, at least so far as can be determined. The width of the bands varies in different species. This character seems to be more common in tropical ascomycetes than in temperate and northern species, having also been observed by the writer in several of the tropical Hypocreales. It has also been mentioned by Doctor Thaxter in the genus *Wynnea* which genus is tropical although one species runs up into the northern United States. There may be no significance in this coincidence but it is sufficiently striking to deserve mention. All of the species examined in the present genus have either fasciculate hairs or striate spores or both; all are bright colored, more or less stipitate, of a tough consistence, grow on wood and have a similar distribution.

The genus *Phillipsia* which is treated in this paper shows a very close relationship with *Cookeina*. One species of the genus has been frequently collected in the West Indies and until recently has been filed away in our collections as an unnamed species of *Sarcoscypha*. In fact the plants very closely resemble our *Sarcoscypha coccinea*. The color of the hymenium is darker being reddish-purple instead of scarlet and the spores are unequal-sided and marked with the striations referred to in connection with *Cookeina*. The great variability in the stem and other gross characters has doubtless led to the multiplication of synonyms in this species. The genus *Phillipsia* was based on specimens in which the stem was almost wanting and had the nature of the plant been fully appreciated it is possible that the species might have been included with the preceding genus. Berkeley in describing *Peziza domingensis*, type of the genus *Phillipsia*, says,—"Though not oblique, it seems to be nearest to such species as *P. onotica*, or perhaps the two pedunculate species which follow [*Peziza Hystrix* and *Peziza Hindsii*]." This is the only reference seen which bears upon the relationship of *Phillipsia* and *Cookeina*. The striation of the spores is a character common to both genera but one which has apparently been overlooked, for it is not usually mentioned in the descriptions of any of the species of either genus except *Peziza striispora* Ellis & Everhart, which is here included as a synonym of *Cookeina Tricholoma*.

These studies are based on material in the herbarium of the Garden including numerous specimens obtained by Garden collectors in the West Indies and Mexico. The collections in several cases are accompanied by colored sketches made in the field by Mrs. Norman Taylor. These sketches show the colors to be a much brighter red than is shown in the published illustrations of the various species which must have been made from dried material or by guess from the descriptions. The photographs are made from dried material which in some cases is partially revived by wetting. On account of the tough consistence of the plants of these two genera they do not shrink a great deal in drying and the photographs compare very favorably with the drawings made from fresh material so far as the form of the cups is concerned. While these photographs do not bring out the colors they show many details which it is impossible to show even in a colored sketch. Drawings are made with the aid of a camera lucida, all spores being drawn to a common scale.

COOKEINA O. Kuntze, Rev. Gen. Pl. 2: 849. 1891

Peziza § *Trichoscypha* Cooke, Mycogr. 252. 1879.
Trichoscypha Sacc. Syll. Fung. 8: 160. 1889. Not *Trichoscypha* Hooker. 1862.
Pilocratera P. Henn. in Engler, Bot. Jahr. 14: 363. 1891.

Plants stipitate or substipitate, bright-colored, some shade of red or yellow, hairy or pruinose; hairs when present fasciculate; substance tough, not shrinking much in drying; asci 8-spored; spores hyaline or subhyaline, ellipsoid to fusoid, usually striate, striations consisting of light and dark bands extending lengthwise of the spore; paraphyses present, filiform.

Type species, *Peziza Tricholoma* Mont.

KEY TO THE SPECIES

Cups clothed with well-developed hairs.
  Hairs long and conspicuous, covering the outside of the cup. *C. Tricholoma.*
  Hairs short and inconspicuous, mostly near the margin of the cup.
    Cups large, shallow; spores 27–33 × 14–18 μ. *C. sulcipes.*
    Cups small, deep; spores 40–50 × 10–12 μ. *C. insititia.*
Cups pruinose but with no well-developed hairs. *C. Colensoi.*

COOKEINA TRICHOLOMA (Mont.) O. Kuntze, Rev. Gen. Pl. 2: 849. 1891

Peziza Tricholoma Mont. Ann. Sci. Nat. II. 2: 77. 1834.

Peziza Hystrix Berk. Ann. Mag. Nat. Hist. II. 9: 201. 1852.

Trichoscypha Tricholoma Sacc. Syll. Fung. 8: 160. 1889.

Pilocratera Tricholoma P. Henn. in Engler, Bot. Jahr. 14: 364. 1892.

Peziza striispora Ellis & Ev. Bull. Lab. Nat. Hist. State Univ. Iowa 4: 69. 1896.

Sarcoscypha striispora Sacc. Syll. Fung. 14: 754. 1899.

Plants stipitate, cup-shaped, with the margin slightly incurved, 1–1.5 cm. in diameter and about 1 cm. deep; stem often so short that the plants appear to be sessile or 2–3 cm. long and about 2 mm. thick, exterior of the cup as well as the stem entirely clothed with long hairs which are more numerous around the margin forming an incurved border, entire plant deep-red or nearly scarlet and a little paler outside, fading in dried plants to pale-orange; hairs often 2–3 mm. long and 100–175 μ in diameter at the base, gradually tapering toward the apex, whitish or pale-brown and composed of a dense fascicle of mycelial threads; asci cylindric, about 350–375 $\times$ 20 μ, abruptly extended below into a short appendage-like base; spores ellipsoid to fusoid, about 27–33 $\times$ 12–14 μ, hyaline or subhyaline with one or two large oil-drops and granular within, usually marked with delicate, longitudinal striations; paraphyses filiform, slender, slightly enlarged upwards.

On old wood and bark.

TYPE LOCALITY, Central America.

DISTRIBUTION: West Indies, Mexico, Central America, and Philippine Islands. Also reported from Australia and South America.

ILLUSTRATIONS: Ann. Sci. Nat. II. 2: *pl. 4, f. 2;* Cooke, Mycogr. *pl. 51, f. 202;* Engler-Prantl, Nat. Pfl. 1[1]: 195, *f. 155*, C-E.

Massee[1] states,—"The two species enumerated above [*Peziza sulcipes* and *Peziza Hindsii*] are synonyms of each other, and in turn both are synonymous with *Peziza tricholoma* Mont." There seems to be no doubt as to the identity of *Peziza sulcipes* and *Peziza Hindsii* but from our own studies based on material col-

[1] Jour. Linn. Soc. 31: 507.

lected in the West Indies, *Peziza Tricholoma* Mont. appears to be distinct. The difference is shown in the accompanying photograph (plate 88).

One new synonym is here added to the list, *Peziza striispora* Ellis & Everhart. This species was described from material collected at Castillo, Nicaragua. The type could not be found in the Ellis Collection but the description, locality, etc, leave little chance for doubt as to its identity.

COOKEINA SULCIPES (Berk.) O. Kuntze, Rev. Gen. Pl. 2: 849. 1891

Peziza sulcipes Berk. in Hooker's London Jour. Bot. II. 1: 141. 1842.

Peziza Hindsii Berk. in Hooker's London Jour. Bot. II. 1: 456. 1842.

?Peziza Afzelii Fries, Nov. Acta Reg. Soc. Scient. Upsal. III. 1: 121. 1855.

Trichoscypha Hindsii Sacc. Syll. Fung. 8: 161. 1889.

Trichoscypha sulcipes Sacc. Syll. Fung. 8: 161. 1889.

?Trichoscypha Afzelii Sacc. Syll. Fung. 8: 161. 1889.

Cookeina Hindsii O. Kuntze, Rev. Gen. Pl. 2: 849. 1891.

?Cookeina Afzelii O. Kuntze, Rev. Gen. Pl. 2: 849. 1891.

?Pilocratera Engleriana P. Henn. in Engler, Bot. Jahr. 14: 363. 1892.

Pilocratera Hindsii Lindau, in Engler-Prantl, Nat. Pfl. 1: 195. 1897.

Geopyxis elata Massee, Bull. Royal Gardens, Kew 1898: 123. 1898.

Plants stipitate, cup-shaped, 1–2 cm. in diameter and about 1 cm. deep or sometimes more shallow, exterior of the cup often marked with several concentric rings near the margin and fringed with very short hairs which are more numerous at or near the margin of the cup, hymenium deep-orange to nearly scarlet, externally paler, fading to pale-yellow in dried specimens; stem often so short that the cups appear to be sessile but occasionally as long as 3 cm. and about 2 mm. thick; hairs comparatively short, subconical in form, about 400–500 μ long and 75–100 μ broad at the base gradually tapering toward the apex, composed of a dense

fascicle of mycelial threads, pale yellow; asci cylindric, about 300–350 × 20 μ with a short appendage-like stem; spores ellipsoid with the ends slightly narrowed, hyaline or subhyaline with one or two large oil-drops and granular within, 27–33 × 14–18 μ, longitudinally marked with delicate striations; paraphyses filiform, slightly enlarged above.

On old wood and bark.

TYPE LOCALITY, Surinam, South America.

DISTRIBUTION: West Indies, Mexico to South America. Also reported from Australia.

ILLUSTRATIONS: Hooker's London Jour. Bot. II. 1: *pl. 15* (in part); Cooke, Mycogr. *pl. 51, f. 199, 200;* Cooke, Australian Fungi, *f. 153;* Engler-Prantl, Nat. Pfl. 1¹: 195, *f. 155, F, G;* Engler, Bot. Jahr. 14: *pl. 6, f. 9.*

One new synonym is added to the list above, *Geopyxis elata* Massee. I have examined the type of this species and find it identical in every respect with *Peziza sulcipes* Berk. While the type of *Pilocratera Engleriana* P. Henn. has not been seen, the description fits this species very closely and it is probably the same. In describing this species Hennings emphasizes the presence of the stripes about the outer margin of the cups which is characteristic of *C. sulcipes.*

COOKEINA INSITITIA (Berk. & Curt.) O. Kuntze, Rev. Gen. Pl. 2: 849. 1891

Peziza insititia Berk. & Curt.; Berk. & Br. Jour. Linn. Soc. 14: 103. 1875.

Trichoscypha insititia Sacc. Syll. Fung. 8: 161. 1889.

Plants deep cup-shaped, stipitate, cup about 5–7 mm. in diameter and of about the same depth, yellow when dry (probably much brighter when fresh), clothed about the margin with rather numerous fasciculate hairs; hairs very broad at the base, often nearly 400–500 μ and 1–2 mm. in length; stem slender, 1–2 mm. in diameter and of variable length but often attaining 1 cm.; asci cylindric, very long, often 500 × 15–18 μ; spores 1-seriate or with the ends overlapping, fusiform, filled with oil-drops and granules, curved or unequal-sided, 40–50 × 10–12 μ, subhyaline; paraphyses filiform, slightly enlarged above.

On wood.

COOKEINA COLENSOI (Berk.) Seaver
COOKEINA INSITITIA (Berk. & Curt.) O. Kuntze
PHILLIPSIA DOMINGENSIS Berk.

TYPE LOCALITY: Peradeniya, Ceylon.

DISTRIBUTION: Philippine Islands, Ceylon, and Bonin Islands,

ILLUSTRATIONS: Cooke, Mycogr. *pl. 51, f. 201;* Jour. Linn. Soc. **31**: pl. 16, f. 26.

This species has not been found in the West Indies so far as known but it is not unlikely that it will be found to occur there. It is closely related to the other members of the genus but can be distinguished by the form of the cups and by differences in the spores.

Cookeina Colensoi (Berk.)

Peziza Colensoi Berk. in Hooker's Fl. New Zealand **2**: 200. 1855.
Peziza aluticolor Berk. Proc. Linn. Soc. **13**: 176. 1873.
Sarcoscypha Colensoi Sacc. Syll. Fung. **8**: 157. 1889.
Geopyxis aluticolor Sacc. Syll. Fung. **8**: 64. 1889.

Plants stipitate or substipitate, shallow cup-shaped, 1–1.5 cm. in diameter and about 5 mm. deep, dried plants pale-yellow (probably much brighter when fresh) marked with concentric rings about the outer margin, externally covered with loose cells which sometimes approach rudimentary hairs but with no well-developed hairs, wrinkled when dry especially near the base of the cup; stem very short or almost wanting, sometimes not more than 1 mm. in length, never long as in related species; asci cylindric, about 400–475 × 20 μ, gradually tapering below; spores 1-seriate or with the ends slightly overlapping, fusoid with the ends quite strongly narrowed, with one or two large oil-drops and granular within, striations consisting of several broad, longitudinal bands extending the length of the spore, 30–40 × 12–15 μ; paraphyses filiform, scarcely enlarged above.

On wood and bark.

TYPE LOCALITY: New Zealand.

DISTRIBUTION: West Indies, New Zealand, Australia, and Africa.

ILLUSTRATIONS: Hooker's Fl. New Zealand **2**: *pl. 105, f. 5;* Cooke, Mycogr. *pl. 50, f. 198.*

The plants of this species examined are almost sessile although the species is often described and illustrated with a stem several mm. long. The stem is probably variable as in other species of the genus although it has never been found to attain the length characteristic of other species of the genus. With the exception

of the shorter stem, and absence of hairs the cups of this species might easily be mistaken for a subsessile form of *Cookeina sulcipes*. The spores however are quite different. *Geopyxis Mölderiana* P. Henn.[2] does not seem to differ materially from this species so far as can be judged from the published description.

PHILLIPSIA Berk. Jour. Linn. Soc. **18**: 388. 1881

Plants attached to the substratum by a very broad base which is often extended into a rather long, thick stem, hymenium bright-colored; substance tough, not shrinking much in drying; asci 8-spored; spores usually striate, subhyaline; paraphyses present, very slender.

TYPE SPECIES, *Peziza domingensis* Berk.

PHILLIPSIA DOMINGENSIS Berk.

Peziza domingensis Berk. Ann. Mag. Nat. Hist. II. **9**: 201. 1852.
Peziza crispata Berk. & Br. Jour. Linn. Soc. **10**: 367. 1869.
Helotium purpuratum Kalchbr. in de Thümen, Myc. univ. 1614. 1880.
?Peziza Harmoge Berk. & Br. Jour. Linn. Soc. **14**: 104. 1875.
Phillipsia kermesina Kalchbr. & Cooke, Grevillea **9**: 25. 1880.
Phillipsia subpurpurea Berk. & Br. Jour. Linn. Soc. **14**: 104. 1875.
Lachnea crispata Sacc. Syll. Fung. **8**: 682. 1889.
Otidea domingensis Sacc. Syll. Fung. **8**: 97. 1889.

Plants shallow cup-shaped, regular or occasionally unequal-sided, attached by a broad base, sometimes nearly as broad as the cup, base often extended into a thickened stem 1 cm. long, hymenium dark reddish-purple, externally much paler, nearly white or with a pinkish tinge or fading to a dirty-yellow in dried plants, more or less downy especially near the base; substance tough and corky in dried plants, hymenium becoming pitted as a result of unequal shrinkage in drying, often giving it the appearance of a resupinate polypore; asci cylindric, about 300–360 × 15–20 μ, gradually tapering below into a long stem-like base; spores 1-seriate or with the ends slightly overlapping, ellipsoid, ends very blunt or more rarely abruptly narrowed, unequal-sided, striated, striations consisting of a few broad bands extending the length

[2] Hedwigia **41**: 30. 1902.

1, 2. COOKEINA TRICHOLOMA (Mont.) O. Kuntze; 3–5. COOKEINA SULCIPES (Berk.) O. Kuntze; 6. COOKEINA INSITITIA (Berk. & Curt.) O. Kuntze; 7. PHILLIPSIA DOMINGENSIS Berk.; 8. COOKEINA COLENSOI (Berk.) Seaver

of the spore, with one or two large oil-drops and often several smaller ones, subhyaline; paraphyses filiform, slightly enlarged at their apices.

On old wood and bark.

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: West Indies, Australia, and Africa.

ILLUSTRATIONS: Cooke, Australian Fungi, *pl. 191, f. 151;* Grevillea 9: *pl. 136, f. 21;* Jour. Linn. Soc. 31: *pl. 16, f. 7, 8 and 9.*

The above are some of the synonyms of this species, which have probably resulted from the great variability of the plants. It is not unlikely that further study of tropical discomycetes will add still other synonyms to the list.

EXPLANATION OF PLATES

PLATE LXXXVIII

Cookeina sulcipes (Berk.) O. Kuntze (upper figure).
Cookeina Tricholoma (Mont.) O. Kuntze (lower figure).

PLATE LXXXIX

Cookeina Colensoi (Berk.) Seaver (upper figure).
Cookeina insititia (Berk. & Curt.) O. Kuntze (middle figure).
Phillipsia domiggensis Berk. (lower figure).

PLATE XC

1. *Cookeina Tricholoma;* ascus, spores and paraphyses.
2. *Cookeina Tricholoma;* hair from outside of cup.
3. *Cookeina sulcipes;* ascus, spores and paraphyses.
4 and 5. *Cookeina sulcipes;* hairs from outside of cup.
6. *Cookeina insititia;* ascus and spores.
7. *Phillipsia domingensis;* ascus and spores.
8. *Cookeina Colensoi;* ascus and spores.

NEW YORK BOTANICAL GARDEN.

TYPE STUDIES IN THE HYDNACEAE[1]— V. THE GENUS HYDNELLUM.

Howard J. Banker

Hydnellum Diabolus sp. nov.

Hydnum carbunculus (Secr.) Banker, Mem. Torrey Club **12**: 151. 1906; not *Hydnum carbunculus* Secr., Myc. Suis. **2**: 515. 1833.

Hymenophore terrestrial, mesopodous, gregarious, more or less confluent, low, nearly sessile, broad; pileus convex to plane, rarely slightly depressed in center, more or less uneven, somewhat round to irregular, 4–10 cm. wide and by confluence often 20 cm. wide; surface wooly pubescent, often more or less floccose squamulose, azonate, whitish at first turning slightly brownish with irregular blotches of dark-brown to nearly black where bruised, these latter spots more or less glabrous, shining, probably from the dried juice; substance fibrous, tough, spongy, grayish-brown in the upper part of the pileus, compact, hard, somewhat woody, more or less distinctly zonate in the lower part, exuding a thick red juice in the fresh plant; margin somewhat thick, obtuse, subfertile to sterile; stem stout, very short, deformed, becoming bulbous in the substratum, and sometimes subradicating, 1–3 cm. wide, 1 mm. to 1 cm. long above ground; teeth slender, terete, tapering, acute, decurrent, pinkish white, less than 5 mm. long shortening to the margin, about 3–5 to a sq. mm.; spores ovoid, tuberculate, brownish, 4–5.5 μ wide; hyphae of pileus hyaline, smooth, thin-walled, collapsing when dried, recovering quickly in KOH, forming a somewhat intricate tangle but with a decided tendency to run longitudinally, separable in KOH, septate with simple clamp-connections, segments extremely long, slender, uniform, 3–4 μ wide, branching diffuse; odor of hickory nuts, strong; taste intensely acrid.

On the ground under conifers in autumn.

The type specimen of this species was collected at Mt. Desert,

[1] Investigation prosecuted with the aid of a grant from the Esther Herrman Research Fund of the New York Academy of Science.

Maine, by Miss V. S. White, No. 148, and deposited in the herbarium of the New York Botanical Garden. The species is found distributed more or less sparingly from Maine to Alabama. The following specimens appear to belong here: Maine, *White;* New Jersey, *Ellis;* Maryland, *Shear;* Alabama, *Earle.* The species is also represented by many of the specimens in the following exsiccati under the name *Hydnum ferrugineum* Fries: Ellis, N. Am. Fung. 928; and Shear, Ell. and Everh. Fung. Columb. Cont. 1409.

In our previous paper, *loc. cit.,* we identified our American plants with Secretan's species solely on the basis of his description. The type of *H. carbunculus* Secr. has not been located and probably is not in existence. No specimens were found in European herbaria referred to his species, and it seems probable that the name is not there recognized as anything more than a synonym of *H. ferrugineum* Fries Secretan himself evidently regarded his species as the same as *H. ferrugineum* Fries and proposed the name on the ground that Fries's name was preoccupied by *H. ferrugineum* Pers. His description, however, does not accord well with authentic specimens of the Friesian species, but does apply well to our American plants.

On the other hand, our plants appear to be entirely distinct from any European forms, as but one doubtful specimen was found in Europe that seemed to show any affinity with the American species. That was a specimen at Upsala received from Karsten and referred to *H. ferrugineum* Fries but was evidently quite different from authentic specimens of that species in the same herbarium. It was not, however, any nearer to our American forms. A specimen from Bresadola in the New York Botanical Garden Herbarium and referred by him to *H. ferrugineum* Fries also somewhat approaches in appearance the American plants but is clearly not the same.

Although Secretan's description is admirably adapted to our American forms, it seems best to treat the American segregation as a distinct species for which we now propose a specific name. Our grounds for this decision are: first, the fact that both by himself as well as by other European mycologists Secretan's species was regarded as equivalent to *H. ferrugineum* Fries; second,

this fact combined with the lack of any specific type is sure to involve any forms referred to Secretan's species in confusion with the Friesian species; third, the Friesian species itself, as we believe, is of doubtful standing and further confusion is likely to be involved with its synonyms; finally, the American form does not appear to be represented in Europe and there is, therefore, reason for serious doubt if Secretan really described the American species.

HYDNELLUM VELUTINUM (Fries) Karst. Medd. Soc. Faun. et Flora Fenn. 5:— (27). 1879

Hydnum velutinum Fries, Sys. Myc. 1: 404. 1821.
Hydnum spongiosipes Peck, Ann. Rept. N. Y. State Mus. 50: 111. 1897.

No specimen whatever referred to *Hydnum velutinum* Fries was found at Upsala. There is probably, therefore, no type specimen of this species. At Berlin no specimens were found under this name except a couple of American plants sent by Atkinson. At Paris, besides a specimen from Massachusetts collected by Sprague, there was only one other specimen which had been collected in "Nantes." At Kew, England, a considerable number of specimens were found under this name, many of which were identical with the American *H. spongiosipes* Pk. as were also the specimens at Berlin and Paris. The latter species is, therefore, evidently a European species though apparently rare on the continent and is known to the European mycologists as *Hydnum velutinum* Fries with the description of which it fully accords.

HYDNELLUM SCROBICULATUM (Fries) Karsten, Medd. Soc. Faun. et Fl. Fenn. 5:— (27). 1879

Hydnum scrobiculatum Fries, Obs. Myc. 1: 143. 1815.
Hydnum ferrugineum Fries, Obs. Myc. 1: 133. 1815; not *H. ferrugineum* Pers. Tent. disp. Meth. Fung. 30. 1797.
Hydnellum sanguinarium Banker, Mem. Torrey Club 12: 152. 1906.

No type specimen of *Hydnum scrobiculatum* Fries was to be found in the herbarium of Fries at Upsala. Plants referred to this

species at Upsala as well as in most other European herbaria are quite variable and show the usual confusion with the closely related species. In general, however, the interpretation of the species by European mycologists appears to be identical with that set forth by the writer in a former paper.[2]

Hydnum ferrugineum Fries as represented at Upsala by specimens of as early a date as 1849 and 1866 does not appear to differ essentially from many of the specimens also there referred to *H. scrobiculatum*. These forms, however, we would refer to *H. hybridum* Bull. Fries himself in the Systema Mycologicum 1: 403 cites *H. hybridum* Bull. as a synonym, but later in the Epicrisis Systematis Mycologici he identified Bulliard's species with his own *H. velutinum* with the emphatic remark "Omnino hoc." A study of Fries's descriptions of *H. ferrugineum* conveys the impression of changing conceptions. In the Observationes Mycologici 1: 133 where the original description is found the species does not appear to differ greatly from our conception of *H. velutinum*. In the Systema Mycologicum *l. c.* the description is far more applicable to the forms which we have regarded as *H. scrobiculatum*. His figure in the Icones Selectae Hymenomycetes *pl. 5. f. 1*, is an excellent representation of what we regard as *H. scrobiculatum*. As to the red juice of which much has been made in later years we do not believe it to be a constant character as we have seen plants that appeared to differ in no other way with clear watery juice, with juice of a pinkish tinge, and with juice that the collector stated was "blood red."

On the basis of the specimens at Upsala, the determination of which from their early date may be regarded as approved by Fries, one would perhaps be justified in treating *H. ferrugineum* Fries as a synonym of *H. hybridum* Bull. but the plants do not accord well with the descriptions and figures. It is perhaps fortunate that *H. ferrugineum* Fries is untenable and that the name must be treated as a synonym, but it is difficult to decide whether it is better regarded as a synonym of *H. scrobiculatum* Fries or of *H. hybridum* Bull. On the whole, we incline to the view that it pertains to the former.

[2] Mem. Torrey Club 12: 156. 1906.

Hydnellum sanguinarium Banker was proposed as a substitute for the untenable *Hydnum ferrugineum* Fries at a time when we regarded the red juice as having much weight in the separation of species. As treated by us in the work cited it differs in no other essential particulars from our treatment of *H. scrobiculatum* Fries.

Hydnellum hybridum (Bull.)

Hydnum hybridum Bull. Hist. Champ. Fr. 307. 1791.
Hydnum Queletii Fries, Quél. Champ. Jura Vosg. 277. 1872.

There is no type of *H. hybridum* Bull. in existence and our forms are referred here solely on the basis of Bulliard's description and figures. The radiating rugae appear to be the most characteristic feature of the segregation. This character, however, is sometimes obscure and it is then difficult to distinguish the plants from *H. scrobiculatum.*

The type of *H. Queletii* is preserved in the herbarium at Upsala and is a typical specimen of the segregation which we refer to *H. hybridum* Bull., having the radiate rugae especially well developed. The plants of this segregation have been quite commonly referred to *H. scrobiculatum* by the most eminent mycologists, often to *H. zonatum* Batsch, and even apparently by Fries himself to *H. ferrugineum* Fries.

Hydnellum Vespertilio (Berk.)

Hydnum Vespertilio Berkeley, Hooker's Jour. Bot. and Kew Gard. Miscel. **6**: 167. 1854.

In the original description of this species Berkeley emphasized the fact that it was black and suggested a possible relationship to *Hydnum nigrum* Fries. This was misleading and, as the description was based on specimens from India and suggested no American forms, little attention was paid to it. In searching through the Berkeley Herbarium at Kew, however, specimens were found marked according to notes taken at the time "Hydnum vespertilio, Berk. Nunklow July 10, 1860." These specimens were at once recognized as similar to certain undetermined American forms belonging in the genus *Hydnellum.* They are undoubtedly the type of Berkeley's species as that author cites for his type

specimens "Nunklow. July 10, 1850." At the time of taking my notes I doubtless mistook the 5 in the year date for a 6 and just then I had no reference to Berkeley's original description for comparison.

The specimens at Kew although very dark are not black and are clearly typical examples of the genus *Hydnellum,* being very near *H. hybridum* and *H. zonatum.* The American forms that belong here have been, doubtless, generally referred to *H. zonatum.* Berkeley's description fits our plants in every respect except for his unqualified statement that the species is black. Fresh living plants have the usual cinnamon-brown color of the related species, sometimes uniform, occasionally with the pink border characteristic of *H. zonatum.* One of the most distinctive features is the rows of scabrous, yellow dots that mark the zonations of the pileus. Old specimens are very dark and the writer has in his herbarium a collection gathered at Bolton, N. Y., that contains one or two old and apparently weathered specimens that are actually black. Nothing so dark was observed in the material at Kew, and we believe that the character pertains only to old dead specimens.

HYDNELLUM ZONATUM (Batsch) Karst. Medd. Soc. Faun. et Fl. Fenn. 5: — (27). 1879

Hydnum zonatum Batsch, Elench. Fung. 111. 1783.
Hydnum concrescens Pers. Obs. Myc. 1: 74. 1796.

There is no type specimen of *Hydnum zonatum* Batsch and our conception of the species is almost wholly dependent upon Batsch's description and figures.

In Persoon's herbarium at Leyden there are a number of specimens under the names *Hydnum concrescens* Pers. and *Hydnum cyathiforme* Bull. which are there treated as synonymous. None of these are probably to be regarded as type specimens although most of them may be considered as having their determination approved by Persoon. The principal set of these appears to be identical with the forms which we have referred to *H. concrescens* Pers.[3] Most of the other specimens are forms which we would refer to *H. hybridum* Bull. In the European

[3] Mem. Torrey Club 12: 157.

herbaria referred the forms generally to *H. zonatum* Batsch are of these two types.

The American form which we have previously referred to this species we are now convinced is not a European plant. Nothing like it has been observed in any of the European collections. We, therefore, return to the prevailing view of the European mycologists and regard *H. zonatum* Batsch as synonymous with *H. concrescens* Pers. It is highly probable that *H. cyathiforme* Bull. should be regarded as of this segregation. At Paris, specimens from Desmaziéres are strictly of this type and are ascribed in common to *Hydnum cyathiforme* Bull., *H. concrescens* Pers., and *H. zonatum* Batsch.

Hydnellum parvum sp. nov.

Hymenophore terrestrial, mesopodous, gregarious, often confluent, small, cinnamon-brown with light margin; pileus subconvex to plane, umbilicate, or subinfundibuliform, irregular, thin, less than 1 mm. thick, 1.5–3 cm. wide; surface radiately fibrillose-striate, subpubescent, distinctly zonate with shades of brown, darker in the center, pink to nearly white toward the margin when fresh, but turning more or less uniform brown when dried; margin thin, acute, repand, more or less lacerate; substance darker and more compact than surface layer, azonate, thin; stem slender, subcylindrical, slightly bulbous at base with scarcely evident spongy tomentum, solid, pubescent, cinnamon-brown, 1–1.5 cm. long, 2–3 mm. wide; teeth slender, terete, tapering, acute, not decurrent, dark-brown, less than 1.25 mm. long, shortening towards margin and stem; spores subglobose, coarsely tuberculate, 3–4 μ wide, brown; hyphae colored brownish, transparent, smooth, somewhat thin-walled, collapsing when dried, recovering but partially in KOH, running distinctly longitudinally and interweaving into a compact layer, separable with difficulty in KOH, septate without clamp-connections, segments extremely long, slender, uniform in width, 3–4 μ wide, branches few, arising at a point about once or twice the width of the hypha below a septum and septate at about three or four times the width of the hypha above its origin.

On ground in dry woods, usually under conifers, in late autumn.

The type specimens were collected by Dr. L. M. Underwood in Alabama and are in the Underwood herbarium at Columbia University.

In a former work[4] these plants were referred to *Hydnellum zonatum* (Batsch) Karst. under a mistaken conception of that species which we have now corrected (see *H. zonatum* above). After a thorough search through a number of the most important European herbaria, we are convinced that the plants are not European forms and should be recognized as a distinct species. The plants do not appear to be common but have a wide distribution, specimens having been seen from New York, Alabama, and Michigan.

HYDNELLUM SUAVEOLENS (Scop.) Karst. Medd. Soc. Faun. et Fl. Fenn **5**: 27. 1879

Hydnum suaveolens Scopoli, Fl. Carn. **2**: 472. 1772.
Hydnum compactum Pers. Comm. Schaeff. 57. 1800.
Hydnum boreale Banker; White, Bull. Torr. Club **29**: 553. 1902.

There is no type specimen of Scopoli's species, but specimens in Europe referred here are generally of the same type as the forms previously described by the writer[5] under this name.

Hydnum compactum Pers. is represented in the Persoon herbarium at Leyden by several specimens some of which are labelled in Persoon's own hand. They do not appear to differ in any respect from the forms usually referred to *H. suaveolens* Scop.

The blue coloration of *H. suaveolens* appears to be quite variable in intensity and doubtless tends to fade with age. In old herbarium specimens it is usually faint. The odor likewise seems to vary in intensity and is probably sometimes nearly, if not wholly, lacking. While in some specimens it can be detected for years in most old herbarium specimens it has evidently disappeared. In the original description of *H. boreale* Banker, the odor was stated as unpleasant on the authority of Miss White's field notes. The odor of these plants is generally described as that of melilot. Such an odor if very strong would probably be unpleasant to some people.

Hydnellum Rickerii sp. nov.

Hymenophore terrestrial, mesopodous, scattered, or solitary, medium to large sized, dingy-brown or olivaceous; pileus depressed

[4] Mem. Torrey Club **12**: 158. 1906.
[5] Mem. Torrey Club **12**: 163. 1906.

to subinfundibuliform, repand, somewhat uneven or rugose, round to slightly irregular, 12–20 cm. wide; surface glabrous, pelliculose, subrugose, dark-dingy-olive-brown near center to chestnut near margin, the coloring somewhat irregularly distributed; margin thin, incurved when dried; substance fibrous to subfleshy, thin, 2–4 mm. thick when dried, dingy-white or slightly tawny with a gradually increasing steel-blue toward center and in stem, homogeneous, azonate; stem short, excentric, with bulbous base; teeth slender, terete, subcylindrical, acute, decurrent, grayish-brown, 7 mm. or less long, shortening toward margin and stem, crowded, 7–9 to a sq. mm.; spores globose to ovoid, tuberculate, pale-brown to hyaline, 3–4 μ wide; hyphae of the pileus hyaline to pale-yellowish, smooth, thin-walled, collapsing when dried, recovering quickly in KOH, running longitudinally but interweaving into a close tangle, separable in KOH with some difficulty, rarely septate with simple clamp-connections, segments extremely long, slender, uniform, 5–6 μ wide, scarcely any branching; odor very strong aromatic with a suggestion of melilot.

The type specimen was collected in Orono, Maine, by P. L. Ricker, No. 173, and is in the writer's herbarium. Part of the same collection is in Mr. Ricker's possession and I believe a specimen is with Prof. Farlow at Harvard University.

While the species approaches *H. suaveolens* in several particulars it differs conspicuously in the darker color of the pileus, the character of the substance which is more nearly fleshy and does not dry hard and woody as in *suaveolens,* and the fragrant, spicy odor. The odor of this plant is the most remarkable of that of any fungus I have seen. It has something of a suggestion of melilot, but the heavy sickening odor of the latter is relieved by a spicy, aromatic quality which makes the fragrance of this plant especially delightful. Two specimens of this plant filled a large laboratory with their odor for many weeks and even after twelve years a fragment of one of these plants still gives a distinct though faint odor. The species is known only from the original collection.

Hydnellum inquinatum sp. nov.

Hymenophore terrestrial, mesopodous, gregarious to confluent, light or dark-brown with light border, medium to large sized; pileus obconic, plane to depressed or subinfundibuliform, somewhat round or elliptical, 5–10 cm. wide, 0.4–1 cm. thick; surface

somewhat uneven, sometimes wrinkled or irregularly corrugated, central portion of disk brownish to dark-brown becoming blackish with age, glabrous or subpubescent, sometimes pelliculose, with a more or less distinct border of whitish or isabelline wooly pubescence 1–2 cm. wide; margin obtuse, entire, substerile; substance in two layers, an upper spongy layer thickest at center and thinning out toward margin, and a lower hard, woody layer extending into and forming the core of the stem, sometimes transversely zonate, light-brown to pallid, hygrophanous, juice watery, colorless; stem central or excentric, short, with a spongy bulbous base, surface more or less uneven, dark-brown to blackish, subpubescent, 1–3 cm. long including the bulbous base, 0.7–1 cm. wide; teeth stout, somewhat compressed, often forked, obtuse to acute, shortening uniformily toward stem and margin, decurrent to the bulbous base, dark-gray-brown at base, lighter toward tip, 5 mm. or less long, 0.1 mm. wide, 6–8 to a sq. mm.; spores brown or fuscous, ovoid, coarsely tuberculate, $4 \times 5\,\mu$ wide; hyphae in the compact portions hyaline, smooth, somewhat thin-walled, collapsing when dried, recovering quickly in KOH, running longitudinally and interwoven, somewhat easily separable in KOH, septate with simple clamp-connections, segments extremely long, slender, uniform, with many guttulae, $4–5\,\mu$ wide, branching diffuse, both filaments septate a little above origin of branch, but only main filament with clamp-connection; in spongy portions hyphae thin-walled, collapsing and not recovering much in KOH, forming an intricate tangle and not separating easily in KOH, septate without clamp-connections and without guttulae, in other respects as the former; odor pleasant somewhat farinaceous, not strong; taste mild.

On ground under hemlocks, in late summer.

The type specimens were collected by the writer near Bolton, N. Y., and are in his herbarium. Specimens of what appear to be the same have been seen from New York, *Underwood*, and from New Hampshire, *Wilson*.

Hydnellum Peckii sp. nov.

Hymenophore terrestrial, mesopodous, gregarious to subconfluent, whitish to brownish gray, small to medium sized; pileus subobconic, plane to depressed, inclined, somewhat round to irregular, 2–5 cm. wide, 2–5 mm. thick; surface uneven, whitish pubescent when young, becoming glabrous and brownish-gray extending from the center finally to the margin; margin thin, acute,

substerile, curling, uneven; substance tough, fibrous, compact, somewhat woody when dry, sometimes with a little spongy layer above at center, light-brown or isabelline; stem central, short, tapering downward into a spongy bulbous base, uneven, pubescent, dark-brownish, about 0.5 cm. long, 4–8 mm. wide, the bulbous base 1–1.5 cm. wide by 2–2.5 cm. long; teeth slender, terete, tapering, acute, shortening uniformly toward stem and margin, dark gray-brown at base, lighter at tip, 3 mm. or less long, 0.25–0.35 mm. wide, 7–9 to a sq. mm.; spores brown or fuscous, slightly tuberculate or angular, subglobose to ovoid, 4–5 μ wide; hyphae hyaline, smooth, somewhat thin-walled, collapsing when dried, recovering quickly in KOH, running longitudinally in compact portion and forming an intricate tangle in spongy portion, easily separable in KOH, slender, uniform, septate with simple clamp-connections, segments extremely long, 3.5–4 μ wide, branching diffuse, both filaments septate, with or without clamp-connections a little above origin.

On ground in woods, in autumn.

The type specimens were collected at North Elba, N. Y., by C. H. Peck, state botanist of New York, after whom the species is named. The specimens are in the writer's herbarium and a portion of the same collection is in the New York state herbarium at Albany. The species is not known outside of the original collection.

Hydnellum geogenium (Fries)[6]

Hydnum geogenium Fries, Ofv. Kongl. Vet. Ak. Forh. **1852**: 127. 1852.

Hydnum sulphureum Kalchbrenner.[7]

The type specimen of the species is to be found at Upsala marked in Fries's handwriting "Hydnum geogenium Fries. Upsaliae." With it are specimens collected by Lindblad at Upsala in 1857, also specimens sent by P. A. Karsten from Mustiala in 1866. All of these agree in their characters and are identical with specimens collected by C. H. Peck in New York.[8] There appears to be no doubt that the species belongs in the genus *Hyd-*

[6] It seems probable that this combination has already been made by Karsten but we have not been able to locate it.

[7] The name is cited by Fries, but we cannot find that the species has ever been described.

[8] Peck, Ann. Rept. N. Y. State Mus. **39**: 43.

nellum although the color is quite unusual and even the spores appear to be yellowish, but we have not seen a spore print. The spores are distinctly tuberculate and the substance of the plant is fibrous and tough.

No type specimen of *H. sulphureum* Kalch. has been seen, but a specimen so labelled from Kalchbrenner, collected in Hungary, was found at Upsala where it had been referred to *H. geogenium* by Fries and appeared to be identical with the type of the latter species in every respect.

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THE AGARICACEAE OF THE PACIFIC COAST—IV. NEW SPECIES OF CLITOCYBE AND MELANOLEUCA

William A. Murrill

Both of these genera are large and difficult, the former being characterized by decurrent or adnate gills and the latter by sinuate or adnexed gills. *Tricholoma* (Fries) Quél. is antedated by *Tricholoma* Benth., so *Melanoleuca* Pat. must be substituted for this familiar name; but combinations with *Tricholoma* are made for those desiring to continue its use.

Clitocybe albicastanea sp. nov.

Pileus convex, gibbous, at length expanded, gregarious or growing in incomplete fairy rings, 1.5–4 cm. broad; surface white, smooth, glabrous, moist, margin entire, concolorous; context thick at the center, very thin near the margin, white, without characteristic taste or odor; lamellae narrow, distant, slightly arcuate, decurrent, white, bay to dark-chestnut in dried specimens; spores ellipsoid, smooth, hyaline, 7–8.5 × 4–5.5 μ; stipe cylindric, equal, smooth, white, glabrous, solid, 3.5–5 cm. long, 3–7 mm. thick.

Type collected among leaves under oaks near Searsville Lake, California, December 28, 1902, *James McMurphy 61*.

Clitocybe albiformis sp. nov.

Pileus thick, firm, convex, cespitose, 5–9 cm. broad; surface nearly smooth, dry, glabrous, white, slightly cremeous at the center, margin entire, concolorous, strongly inflexed on drying; context thick, white, with the odor and taste of the ordinary field mushroom; lamellae distinctly decurrent, rather broad and close, several times inserted, plane or arcuate; spores globose, smooth, hyaline, 2–3 μ; stipe cylindric to ventricose, tapering upward at times, white, solid, slightly fibrillose below, finely tomentose above, 9–16 cm. long, 1–2.5 cm. thick.

Type collected in humus under redwoods near Searsville Lake, California, January 6, 1903, *James McMurphy 3*. This species

strongly suggests *Tricholoma album,* hence the specific name selected for it.

Clitocybe atrialba sp. nov.

Pileus convex to slightly depressed and at length infundibuliform, regular in outline, solitary or gregarious, reaching 6 cm. broad; surface at first smooth, glabrous, dry, fuliginous-ater, becoming finely imbricate from the breaking up of the cuticle; margin entire, concolorous, strongly inflexed on drying; context thin, white, tough, with mild flavor; lamellae decurrent, not crowded, white, becoming grayish-discolored; spores globose to subglobose, smooth, hyaline, granular, 8.5–10 × 7–8 μ; stipe equal or slightly tapering upward, flattened or twisted at times, dry, furfuraceous or finely scabrous, avellaneous, hollow, with rather tough rind, 5–10 cm. long, 6–10 mm. thick.

Type collected on decayed buried wood in the woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 259.* Also collected in the same locality, *W. A. Murrill 249,* and on decayed buried wood at La Honda, near Palo Alto, California, November 25, 1911, *W. A. Murrill & L. R. Abrams 1263.* This species is rather tough for *Clitocybe,* somewhat resembling *Collybia platyphylla.* It is characterized by its dark-brown cap, white gills, and concolorous, furfuraceous stipe. The spores are also very characteristic in size and appearance.

Clitocybe avellaneialba sp. nov.

Pileus large, thin, slightly umbonate, becoming infundibuliform, gregarious to cespitose, reaching 10 cm. or more broad; surface hygrophanous, avellaneous to dark-fuliginous, subzonate, innate-radiate-fibrillose, hispid-fibrillose in the center, margin entire, concolorous; context thin, white, of mild flavor; lamellae short-decurrent, rather close and narrow, white; spores globose, smooth hyaline, 7–8 × 5 μ; stipe tapering upward, whitish-mycelioid at the base, avellaneous, finely fibrillose to glabrous, solid or hollow with a tough rind, reaching 10 or more cm. long and 1 cm. thick.

Type collected in humus on the ground in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 526.* Also collected in humus under a log in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 293;* and among leaves and sticks under redwoods near Searsville Lake, California, January 6, 1903, *James McMurphy 2.* This species

resembles *C. atrialba* and, like that species, reminds one of *Collybia platyphylla*. It is characterized by its innate-fibrillose, avellaneous cap and glabrous or finely fibrillose stem.

Clitocybe brunnescens sp. nov.

Pileus rather thin, slightly depressed, rarely infundibuliform, reaching 4 cm. broad; surface slightly viscid when moist, smooth, glabrous, dull-avellaneous, margin entire, concolorous; context thin, whitish, with strongly farinaceous odor; lamellae decurrent, subcrowded, narrow, dull-avellaneous, becoming dark-fuliginous, especially on the edges; spores globose, smooth, hyaline, 3–3.5 μ; stipe subequal, smooth, glabrous, concolorous above, whitish-tomentose below, stuffed or hollow, 3–4 cm. long, 4–7 mm. thick.

Type collected among sticks in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 699*. This species is similar in form and color to *C. cyathiformis,* but differs decidedly in its spore characters, as well as in other important ways.

Clitocybe cuticolor sp. nov.

Pileus convex to subplane, thin, 3 cm. broad; surface smooth, glabrous, hygrophanous, dull-rosy-isabelline with a fulvous tint, margin entire, concolorous, incurved on drying; lamellae adnate, close, nearly plane, narrow, dull-rosy-isabelline; spores broadly ellipsoid, smooth, hyaline, about 4.5 × 3.5 μ; stipe eccentric, tapering upward from a bulbous base, fleshy, solid or stuffed, smooth, glabrous, rosy-isabelline, 4 cm. long, 7 mm. thick.

Type collected on the ground in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 532*. This species is colored throughout very much like the skin on the back of a man's hand. Its affinities are with *Tricholoma,* reminding one of *Tricholoma nudum,* but the gills are distinctly adnate, not at all sinuate.

Clitocybe griseifolia sp. nov.

Pileus large, fleshy, convex to expanded or slightly depressed, usually solitary, reaching 9 cm. broad; surface slightly viscid when moist, smooth, glabrous, grayish-white, avellaneous, tinted with brownish-avellaneous at the center, margin thin, somewhat lobed, slightly paler, strongly incurved on drying; context white, fragrant; lamellae rather broad and close, short-decurrent or

rarely adnate, grayish to dirty-white; spores ellipsoid, smooth, hyaline, 5–6 × 3–3.5 μ; stipe bulbous, tapering upward, smooth, glabrous, stuffed, white, 6–9 cm. long, about 1 cm. thick, 2 cm. or more thick at the base.

Type collected in humus in the woods near Seattle, Washington, October 1, 1911, *W. A. Murrill 276.* Also collected in humus in woods at Newport, Oregon, November 13, 1911, *W. A. Murrill 1088,* and on the ground at Mill Valley, Marin County, California, December 28, 1902, *Alice Eastwood 24.*

Clitocybe Harperi sp. nov.

Pileus convex to plane, subcespitose, reaching 8–10 cm. broad; surface dry, smooth, glabrous, cinereous to pale-murinous, margin entire, concolorous, inrolled; context white, taste mild; lamellae short-decurrent, of medium distance, narrow, slightly arcuate or plane, several times inserted, cinereous, sometimes with a greenish tint; spores ovoid, smooth, hyaline, 3.5–5 × 2–3.5 μ; stipe bulbous, whitish-mycelioid at the base, concolorous, pruinose, hollow, 3–7 cm. long, 1–3 cm. thick.

Type collected in Golden Gate Park, San Francisco, California, February 22, 1911, *R. A. Harper 57.* Young specimens with undeveloped spores collected in the Santa Cruz Mountains, December, 1895, *W. R. Dudley 102,* appear to belong to this category. What appears to be the same species was collected on the ground in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 637,* but the cap is avellaneous and the gills crowded and without a greenish tint. The species is similar to specimens of *T. maculatescens* Peck collected in Ohio by Morgan, but the gills are decidedly sinuate in that species and become spotted with age.

Clitocybe hondensis sp. nov.

Pileus convex, gibbous, solitary, 3 cm. broad; surface dry or moist, smooth, glabrous, subfulvous, minutely radiate-lineate, margin thin, entire, paler; lamellae decurrent, arcuate, many times inserted, close, pallid; spores ellipsoid, smooth, hyaline, 5.5 × 3.5 μ; stipe equal, crooked, whitish, smooth, glabrous, hollow, 6 cm. long, 6 mm. thick.

Type collected in rich soil under redwoods at La Honda, near

Palo Alto, California, November 25, 1911, *W. A. Murrill & L. R. Abrams 1274.*

Clitocybe murinifolia sp. nov.

Pileus convex to slightly depressed, rather thin, solitary, about 2 cm. broad; surface smooth, glabrous, smoky-brown, margin thin, slightly lobed, concolorous, inflexed on drying, pruinose when young; lamellae short-decurrent, not crowded, rather narrow, murinous; spores globose, smooth, hyaline, 2–3 μ; stipe fleshy, slightly tapering upward, smooth, glabrous, murinous, solid, whitish-tomentose at the base, 2 cm. long, 7–9 mm. thick.

Type collected on humus in the woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 300*[a].

Clitocybe oculata sp. nov.

Pileus convex to plane, slightly depressed at the center, thin, solitary, reaching 4.5 cm. broad; surface dry, smooth, finely furfuraceous, avellaneous, fuliginous at the center, margin very thin, entire, even, concolorous; lamellae short-decurrent, distant, white; spores broadly ovoid, smooth, hyaline, granular, 9–12 × 7–8 μ; stipe equal, twisted, hollow, with a tough rind, furfuraceous, whitish with a pale-avellaneous tint, 6 cm. long, 5 mm. thick.

Type collected in low woods, probably attached to buried wood, at Mill City, Oregon, November 9, 1911, *W. A. Murrill 835.* The stipe of this species is rather tough for *Clitocybe.* The species is characterized by its coloring, its furfuraceous surface, and its unusually large spores.

Clitocybe oreades sp. nov.

Pileus large, fleshy, convex, becoming plane or slightly depressed with age, usually growing in circles, 6–10 cm. broad, very thick at the center; surface smooth, somewhat viscid when moist, glabrous, shining, cinereous to murinous, sometimes covered with a whitish mold, margin entire, concolorous, deflexed when young, at times becoming upturned and more or less split with age; context thick, white, with an agreeable but not characteristic taste and odor; lamellae short-decurrent, varying to adnate, especially when young, close, narrow, arcuate, white or pale-yellowish-white; spores ellipsoid, smooth, hyaline, 6–8 × 2–4 μ; stipe very large, enlarged or bulbous below, fleshy, white or slightly cinereous, smooth, minutely tomentose or fibrillose above, solid, 10–15 cm. long, 1.5–2.5 cm. thick, reaching 4 cm. or more at the base.

Type collected in humus under redwoods near Searsville Lake, California, December 11, 1911, *James McMurphy 91.* Also collected in a similar habitat near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 280;* near Seattle, Washington, 1912, *S. M. Zeller 99, 123;* near Salem, Oregon, January, 1911, *Morton E. Peck;* in Marin County, California, December 21, 1902, *Alice Eastwood 36;* at La Honda, California, November 22, 1902, *L. R. Abrams 1.* This large and handsome species grows in conspicuous fairy rings. As the above collections indicate, it is quite widely distributed on the Pacific Coast.

Clitocybe oregonensis sp. nov.

Pileus umbilicate to infundibuliform, rather thin, solitary, reaching 4 cm. broad; surface smooth, glabrous, hygrophanous, pale-isabelline, margin thin, entire, concolorous; lamellae short-decurrent, subdistant, narrow, arcuate, discolored on drying; spores ellipsoid, smooth, hyaline, $8.5 \times 7\,\mu$; stipe fleshy, tapering upward, smooth, glabrous, concolorous, 5 cm. long, 5 mm. thick.

Type collected on the ground in mixed woods at Mill City, Oregon, November 9, 1911, *W. A. Murrill 865.* Also collected in mixed woods near Corvallis, Oregon, November 6–11, 1911, *W. A. Murrill 989.*

Clitocybe Peckii sp. nov.

Pileus irregular in outline, umbilicate to depressed, rather deeply depressed on drying, gregarious, reaching 5 cm. broad; surface hygrophanous, smooth, glabrous, grayish-stramineous, faintly radiate-striate on drying, margin thin, somewhat lobed, concolorous, becoming upturned; lamellae discolored, rather close, short-decurrent; spores ovoid, smooth, hyaline, $5–6 \times 2–3\,\mu$ stipe slightly tapering upward, concolorous, smooth, glabrous, hollow or stuffed, reaching 4 cm. long and 7 mm. thick.

Type collected in soil near Salem, Oregon, January, 1911, *Morton E. Peck 20.*

Clitocybe stipitata sp. nov.

Pileus large, fleshy, convex to nearly plane, gregarious, 8–10 cm. broad; surface smooth, glabrous, slightly viscid when moist, white, becoming cream-colored on drying, margin entire or slightly

lobed, rather thick and fleshy, concolorous; lamellae broad, crowded, decurrent, white; spores globose, smooth, hyaline, 4–6 μ; stipe equal, very long, crooked, smooth, subglabrous, whitish-mycelioid below, white, becoming reddish-brown in some specimens on drying, solid or spongy within, 15 or more cm. long, about 1.5 cm. thick.

Type collected among leaves in woods at Stanford University, California, in 1907, *Miss A. M. Patterson*. There are no notes accompanying this collection and the above description is drawn from the dried specimens.

Clitocybe subcandicans sp. nov.

Pileus convex to plane, rather thin, solitary, reaching 6 cm. broad; surface stramineous, smooth, glabrous, hygrophanous, margin white; lamellae decurrent, arcuate, close; spores globose or subglobose, smooth, hyaline, 6–7 μ; stipe cylindric, equal, concolorous, subfleshy, hollow, 6 cm. long, 5–7 mm. thick.

Type collected on the ground among fallen twigs in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 230*.

Clitocybe subinversa sp. nov.

Pileus convex, slightly depressed, rather thin, gregarious, 3–5 cm. broad; surface smooth, moist, glabrous, very light-brown, fulvous when dry, margin thin, incurved, entire, somewhat irregular, concolorous; context cream-colored, without characteristic taste or odor; lamellae decurrent, close, narrow, arcuate, many times inserted, rather firm, white; spores globose or subglobose, smooth, hyaline, 3–4.5 μ; stipe cylindric, equal, somewhat crooked, tomentose or fibrillose, subglabrous, paler than the pileus, hollow, 3–7 cm. long, 3–6 mm. thick.

Type collected in humus under redwoods at Portola, California, January 4, 1903, *James McMurphy 50*. Specimens collected at Salem, Oregon, January, 1911, by Morton E. Peck agree fairly well with this species but also closely resemble *C. sinopica*. No notes accompany the specimens.

Clitocybe subfumosipes sp. nov.

Pileus small, rather thin, convex to plane, gregarious to subcespitose, 2.5 cm. broad; surface white, smooth, glabrous, shin-

ing, avellaneous on the small umbo, margin entire, concolorous, inflexed on drying; lamellae decurrent, rather broad and distant, white, becoming discolored on drying; spores ellipsoid, smooth, hyaline, 5–6 × 2.5–3.5 μ; stipe equal, smooth, pruinose, especially above, white changing to pale-fumosus on drying, hollow, 3–4 cm. long, 2–3 mm. thick.

Type collected in humus in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 316.*

Clitocybe variabilis sp. nov.

Pileus fleshy but rather thin, plane or slightly depressed, rarely umbonate when young, gregarious, reaching 6 cm. broad; surface dry, smooth, glabrous, white, margin thin, usually entire, concolorous; lamellae narrow, usually more or less crowded, decurrent, white; spores ovoid, smooth, hyaline, uninucleate, about 6 × 4 μ; stipe tapering upward from a thickened base, smooth, glabrous, white, whitish-mycelioid at the base, hollow, reaching 6 cm. broad and 8 mm. thick, scarcely 3 cm. long in one collection.

Type collected in humus in woods, near Mill City, Oregon, November 9, 1911, *W. A. Murrill 797.* Also collected on the ground in fir forests near Corvallis, Oregon, *November* 6–11, 1911, *W. A. Murrill 897,* and in a similar locality near Salem, Oregon, January, 1911, *Morton E. Peck.* This species varies greatly in the length of the stipe and the closeness of the gills. The specimens collected near Corvallis differ so greatly from the types in these two characters as to constitute a distinct variety, which may be called *Clitocybe variabilis brevipes.*

Clitocybe violaceifolia sp. nov.

Pileus convex, somewhat gibbous, solitary, 3 cm. broad; surface slightly viscid when moist, smooth, glabrous, grayish-violet tinted with brown at the center, margin entire, slightly paler; lamellae very narrow, adnexed to slightly decurrent, rather crowded, arcuate, pale-violet; spores ellipsoid, smooth, hyaline, 7–8 × 3.5–4.5 μ; stipe equal, fleshy, solid, smooth, glabrous, grayish-violet, mycelioid at the base, 3 cm. long, 6 mm. thick.

Type collected on decaying wood near Salem, Oregon, January, 1911, *Morton E. Peck.*

Clitocybe washingtonensis sp. nov.

Pileus fleshy, convex to plane or very slightly depressed, usually gibbous, gregarious, reaching 5–6 cm. broad; surface white, smooth, glabrous, dry, somewhat shining, margin entire, concolorous; lamellae decurrent, distant, rather narrow, white to slightly discolored; spores ovoid, smooth, hyaline, 7–8 × 3–4 μ; stipe subequal, fleshy, solid or stuffed, smooth, glabrous, whitish-mycelioid at the base, 3.5–5 cm. long, 5–8 mm. thick.

Type collected in humus in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 615*[a].

Melanoleuca anomala sp. nov.

Pileus very small, plane, solitary, 2 cm. broad; surface ferruginous, dry, decorated with dense, minute fascicles of hairs, margin entire, concolorous or slightly paler; lamellae adnate to slightly sinuate, broad, not crowded, ventricose, white, becoming latericious when bruised; spores ellipsoid, smooth, hyaline, 5–6 × 3–4 μ; stipe cylindric, equal, fragile, smooth, glabrous above, fibrillose below, isabelline, solid or stuffed, 3.5 cm. long, 3 mm. thick.

Type collected in soil under redwoods at Preston's Ravine, near Palo Alto, California, November 25, 1911, *W. A. Murrill & L. R. Abrams 1198*. This species is quite different from other members of this group, its appearance indicating ferruginous rather than hyaline spores.

Melanoleuca arenicola sp. nov.

Pileus convex to subexpanded, umbonate, terraced, reaching 10–12 cm. broad; surface smooth, glabrous, ferruginous, apparently viscid when fresh, bringing up adhering particles of sand; context mild to the taste, but with a strong, unpleasant odor; lamellae sinuate, ventricose, crowded, pallid, becoming discolored with subferruginous blotches; spores globose or subglobose, smooth, hyaline, with granular contents, about 4 μ; stipe long, slightly attenuate downward, fleshy, white, glabrous, except for a few fibrils where the margin of the pileus rested against the stipe, reaching 10 cm. long, and 2 cm. thick.

Type collected in deep, pure sand in pine barrens at Newport, Oregon, November 13, 1911, *W. A. Murrill 1035*.

Melanoleuca avellanea sp. nov.

Pileus convex, becoming plane, thick, fleshy, solitary, reaching 8 cm. broad; surface dry, smooth, glabrous, avellaneous, margin entire, concolorous, inflexed on drying; lamellae slightly sinuate varying to adnate, close, narrow, arcuate, pure-white changing to yellowish on drying; spores ellipsoid, smooth, hyaline, about $7 \times 3\,\mu$; stipe much enlarged at the base, rather short, fleshy, solid, white, smooth, slightly scabrous above, about 7 cm. long and 2 cm. thick, reaching 4 cm. thick at the base.

Type collected in sandy soil mixed with humus, in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 267*. Also collected on decayed wood in the same locality, *W. A. Murrill 274*.

Melanoleuca avellaneifolia sp. nov.

Pileus fleshy, rather thick, convex to expanded, gibbous, subcespitose, reaching 9 cm. broad; surface polished, smooth, somewhat viscid, dull-blackish-fuliginous, margin entire, concolorous, inflexed on drying; lamellae sinuate, ventricose, several times inserted, not crowded, pale-avellaneous; spores subglobose, smooth, hyaline, granular, about 5.5–6.5 μ; stipe equal, fleshy, solid, smooth, glabrous, pure-white, about 8 cm. long, 1.5 cm. thick.

Type collected in soil in woods at Mill City, Oregon, November 9, 1911, *W. A. Murrill 841*. Several plants were found, but only one was saved, owing to the bad weather.

Melanoleuca bicolor sp. nov.

Pileus very firm, convex to nearly plane, somewhat gibbous, about 6 cm. broad; surface dry, smooth, glabrous, avellaneous with a rosy tint, margin concolorous or slightly paler, often splitting; lamellae broad, rather close, emarginate with a slight decurrent tooth, firm, drying readily, white; spores subglobose, smooth, hyaline, 6–7 μ; stipe equal or somewhat enlarged below, white, smooth, minutely tomentose to glabrous, solid, 5–6 cm. long, about 1 cm. thick.

Type collected in humus in woods at Glen Brook, Oregon, November 7, 1911, *W. A. Murrill 745*. What appears to be the same species was collected on the ground under an oak at Mission Cañon, California, spring of 1913, *O. M. Oleson 113*[a]. These

latter specimens are very much larger than the types, measuring in the dry state as much as 10 cm. broad with a bulbous stipe reaching 6 cm. long and 3.5 cm. thick. The color is also much darker and is recorded by the collector as brown. The margin in the dried specimens is quite conspicuously striate. The typical specimens are very closely related to *Melanoleuca roseibrunnea*, but differ in color and in the shape and closeness of the gills.

Melanoleuca californica sp. nov.

Pileus convex to subplane, rather thick at the center, gregarious, reaching 15 cm. broad; surface smooth, glabrous, evidently viscid when fresh, bringing up adhering particles of soil, reddish-brown at the center, much lighter-colored at the margin, which is thin, entire and inflexed on drying; context white, rather thick at the center, thinning out toward the margin, slightly bitter to the taste, odor musty; lamellae quite narrow, less than the thickness of the context, sinuate to adnexed, plane, crowded, white, scarcely changing color on drying; spores broadly ellipsoid, smooth, hyaline, $5–7 \times 4–5\,\mu$; stipe very long, subequal, smooth, glabrous, white, solid, 10–15 cm. long, reaching 3 cm. thick.

Type collected under oaks on Jasper Ridge near Stanford University, January 11, 1911, *James McMurphy 125*. This large and handsome species resembles specimens determined as *Armillaria subannulata* Peck sent to Albany from Claremont, California, by Baker. Specimens collected by Oleson at Santa Barbara, California, apparently belong to this category, but they are rather poorly preserved and are not accompanied by notes.

Melanoleuca collybiiformis sp. nov.

Pileus broad, thin, convex to plane, drying easily like species of *Collybia*, gibbous, reaching 10 cm. broad; surface dry, smooth, glabrous, fulvous at the center, pale-fulvous near the entire, smooth margin; lamellae rather crowded, white, sinuate, the edges undulate or somewhat notched; spores globose or subglobose, smooth, hyaline, conspicuously granular within, about $3.5\,\mu$; stipe eccentric, bulbous, rather broad, fleshy, hollow, white, radicate, 6 cm. long, 1–2 cm. thick.

Type collected in humus in a grove at Woodland Park, Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 322*.

This species is closely related to some species of *Collybia*. The eccentric position of the stipe was doubtless due to the peculiar situation in which the plant grew.

Melanoleuca dryophila sp. nov.

Pileus convex, gibbous, becoming almost expanded, scattered, 3–10 cm. broad; surface glabrous, viscid when fresh, subshining, nearly smooth, whitish, stained with rusty-brown, margin paler, somewhat lobed or irregular; context white, with farinaceous taste and odor; lamellae deeply sinuate to adnexed, close, narrow, plane, white, scarcely changing on drying; spores globose, smooth, hyaline, 5–8 μ; stipe cylindric or slightly flattened, scarcely enlarged below, glabrous, nearly smooth, whitish or brownish, solid, 6–8 cm. long, 1–3 cm. thick.

Type collected in soil under live oaks at Stanford University, California, January 21, 1903, *James McMurphy 27*. This species somewhat resembles M. *subpessundata*, but differs in several important characters.

Melanoleuca farinacea sp. nov.

Pileus rather thin but fleshy, convex to expanded, umbonate, gregarious to subcespitose, reaching 8 cm. broad; surface white, smooth, glabrous, margin entire, concolorous; context white, with strong farinaceous odor; lamellae sinuate, broad, several times inserted, not crowded, ventricose, white; spores globose, smooth, hyaline, 4.5–6.5 μ; stipe bulbous and whitish-mycelioid at the base, white, subglabrous, smooth, stuffed or hollow, fleshy, 5–6 cm. long, 5–10 mm. thick.

Type collected in humus in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 644*.

Melanoleuca Harperi sp. nov.

Pileus broad, rather thin, becoming plane or depressed, gregarious or growing in circles, reaching 10–15 cm. broad; surface umbrinous, hygrophanous, not viscid, smooth, glabrous, margin entire or slightly lobed, concolorous; lamellae sinuate, white, not spotted, crowded, rather broad, ventricose, usually separating from the stipe with age; spores broadly ellipsoid, smooth, hyaline, 7–8 $\times$ 4 μ; stipe very short and thick, bulbous, solid, smooth, glabrous, white, about 3–4 cm. long, and 2–3.5 cm. thick.

Type collected in rich soil at Berkeley, California, January 31, 1911, *R. A. Harper 12.* Also collected by Harper in the same locality on February 6, 1911, and February 14, 1911. The species was found on one occasion growing in a fairy ring.

Melanoleuca nuciolens sp. nov.

Pileus convex to nearly plane, often becoming depressed and irregular with age, gregarious, subcespitose, reaching 6 cm. broad; surface glabrous, rather uneven, hygrophanous, pale-rosy-isabelline, margin concolorous, undulate to conspicuously lobed and upturned with age; context white, thin, having the odor of walnuts in dried specimens; lamellae sinuate varying to adnate, narrow, arcuate, rather distant, pale-rosy-isabelline, becoming slightly purplish-spotted when bruised or on drying; spores ellipsoid, smooth, hyaline, $6 \times 3.5\,\mu$; stipe equal or slightly tapering upward, sometimes distorted in old specimens, smooth, glabrous, pallid, hollow, almost cartilaginous, about 5–6 cm. long, 1–1.5 cm. thick.

Type collected in sandy soil in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 658.*

Melanoleuca Olesonii sp. nov.

Pileus convex to plane, large, rather thick at the center, fleshy, gregarious, reaching about 14 cm. broad; surface pure-white, smooth, glabrous, moist, margin thin, entire or slightly lobed, concolorous, not inflexed on drying; lamellae broad, ventricose, crowded, sinuate, white becoming discolored on drying; spores ellipsoid, smooth, hyaline, $7–9 \times 4–5\,\mu$; stipe short, thick, equal or slightly bulbous, smooth, glabrous, white, solid, about 4–5 cm. long and 2–3 cm. thick.

Type collected on the ground under an oak at Mission Cañon near Santa Barbara, California, spring of 1913, *O. M. Oleson 100.* Also collected February 17, 1894, *M. T. Cook 8.* The above description is drawn from dried specimens.

Melanoleuca oreades sp. nov.

Pileus becoming broadly convex or plane to somewhat depressed, large, fleshy, growing in circles, subcespitose at times, reaching 15 cm. broad; surface dry, smooth, slightly silky-striate, pale-avellaneous; context with an agreeable, nutty flavor and an

odor somewhat suggestive of skunk cabbage; lamellae slightly sinuate, crowded, narrow, white, discolored on drying; spores globose, smooth, hyaline, 4–6 μ; stipe cylindric, solid, fleshy, white or pale-avellaneous, 5–8 cm. long, 1–1.5 cm. thick.

Type collected in the edge of woods on the border of a lake near Tacoma, Washington, October 26, 1911, *W. A. Murrill 732.* Seventy-seven plants of this species were found growing there in a perfect circle thirty feet in diameter.

Melanoleuca pinicola sp. nov.

Pileus rather thin, convex, umbonate, becoming nearly plane, gregarious, reaching 5 cm. broad; surface smooth, glabrous, subshining, dry or slightly moist, milk-white, margin entire, concolorous, strongly inflexed on drying; lamellae sinuate, not crowded, rather broad, plane or slightly ventricose, white or slightly discolored; spores ellipsoid, smooth, hyaline, 5–6 $\times$ 3–4 μ; stipe slightly tapering upward, fleshy, solid or stuffed, milk-white, smooth, glabrous, whitish-mycelioid at the base, 5–7 cm. long, 4–9 mm. thick.

Type collected on much decayed, coniferous wood near Tacoma, Washington, October 20–November 1, 1911, *W. A. Murrill 730.*

Melanoleuca platyphylla sp. nov.

Pileus convex to slightly depressed, rather thick, solitary, 3.5 cm. broad; surface smooth, subglabrous, white with a cremeous tint, margin entire, concolorous; lamellae white, subdistant, ventricose, very broad; spores ellipsoid, smooth, hyaline, granular, 8.5 $\times$ 6 μ; stipe tapering upward from a swollen base, pure-white, smooth, glabrous, 8 cm. long, 5–9 mm. thick.

Type collected in humus in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 419.*

Melanoleuca portolensis sp. nov.

Pileus rather thick, convex with a prominent umbo, becoming nearly plane, scattered, 6–11 cm. broad; surface smooth, moist, glabrous, brownish-gray, darker toward the center, margin entire, concolorous; context white, with a slightly nutty taste but without characteristic odor; lamellae rather narrow, slightly sinuate, plane, several times inserted, crowded, white; spores ovoid

smooth, hyaline, 5–7 × 2.5–3.5 μ; stipe tapering upward from an enlarged base, nearly white, smooth above, somewhat roughened below, glabrous, solid, 6–8 cm. long, 1.5–2 cm. thick; veil rudimentary, leaving a trace upon the stipe.

Type collected on the ground under redwoods at Portola, California, January 4, 1903, *James McMurphy 23*. This species resembles *M. dryophila,* but differs in habitat, coloring, and spore characters.

Melanoleuca roseibrunnea sp. nov.

Pileus convex to somewhat depressed, gregarious, reaching 8–10 cm. broad; surface smooth, dry, glabrous, brownish-pink with browner circular spots, margin paler with a cremeous tint, somewhat irregular, and often upturned with age; context white, odor farinaceous, taste farinaceous with a faint bitter flavor which gradually becomes stronger, eaten by slugs; lamellae sinuate with a decurrent tooth, very close, several times inserted, white; spores subglobose to ovoid, smooth, hyaline, 5–7 × 4–5 μ; stipe cylindric, equal or at times enlarged at the base, smooth, finely tomentose to subglabrous, white or whitish, solid, 6–8 cm. long, 1–1.5 cm. thick, usually thicker at the base.

Type collected among humus on the ground in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 375*. Also collected in a similar habitat near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 237, S. M. Zeller 81;* near Corvallis, Oregon, November 6–11, 1911, *W. A. Murrill 894;* near Stanford University, California, January 4, 1903, *James McMurphy 24;* and at Pasadena, California, December 22, 1895, *A. J. McClatchie 1018*. This species is closely allied to *Tricholoma album,* but differs decidedly in color.

Melanoleuca rudericola sp. nov.

Pileus rather thin, broad, somewhat irregular, convex to plane, scattered, 10–14 cm. broad; surface smooth, glabrous, slightly moist light-buff, margin thin, entire to lobed, concolorous; context white, without characteristic odor or taste; lamellae sinuate, narrow, subcrowded, many times inserted, white; spores ellipsoid, smooth, hyaline, 5–7 × 2.5–4.5 μ; stipe cylindric, equal, scarcely enlarged at the base, grayish-white with a tinge of purple, smooth, glabrous, solid, 5–10 cm. long, 1–1.5 cm. thick.

Type collected in rich ground by a heap of rubbish at Madera Creek, California, December 21, 1902, *James McMurphy 18*.

Melanoleuca secedifolia sp. nov.

Pileus thick, fleshy, convex, not fully expanding, solitary, reaching 9 cm. broad; surface smooth, glabrous, somewhat viscid when young, pure-white, subshining, margin entire, concolorous, inflexed on drying; lamellae broad, crowded, slightly sinuate, ventricose, becoming widely separated from the stipe, white changing to dull-brownish on drying; spores subglobose, smooth, hyaline, 5–6 μ; stipe equal, much enlarged at the base, white, smooth, glabrous, solid or stuffed, 8 cm. long, 2.5 cm. thick, about 4 cm. at the base.

Type collected on the ground near Salem, Oregon, January, 1911, *Morton E. Peck 34.*

Melanoleuca striatella sp. nov.

Pileus convex and gibbous when young, becoming depressed with age, firm, fleshy, scattered, 5–7.5 cm. broad; surface smooth, subglabrous, pale-mouse-gray, very minutely striate except at the center, margin quite thick, entire, concolorous; context grayish-white with farinaceous taste, quite thick at the center, but very thin toward the margin; lamellae sinuate to adnexed, broad, plane or ventricose, close, white; spores globose, smooth, hyaline, 5–7 μ; stipe cylindric or slightly compressed, equal, longitudinally striate, whitish, solid, 3–6 cm. long, 1–2 cm. thick.

Type collected on the ground under live oaks at Stanford University, California, January, 1903, *James McMurphy 29.*

Melanoleuca sublurida sp. nov.

Pileus firm, conic to convex with prominent umbo, solitary, 7 cm. broad; surface smooth, minutely squamulose, whitish with a caesious tint, the center black, smooth, and shining, margin entire or slightly undulate, white, deflexed on drying; lamellae sinuate, plane, broad, whitish, distant; spores subglobose, smooth, hyaline, 3–4 μ; stipe subequal, dry, white with grayish, farinaceous scales, solid, about 6 cm. long, and 1.5 cm. thick.

Type collected in soil in woods at Glen Brook, Oregon, November 7, 1911, *W. A. Murrill 751.* This species is very similar to specimens of *T. luridum* sent from Sweden by Romell.

Melanoleuca submulticeps sp. nov.

Pileus large, fleshy, convex to plane, becoming depressed with age, densely cespitose, reaching 10–12 cm. broad; surface smooth,

glabrous, hygrophanous, white, margin entire, concolorous; lamellae sinuate, rather crowded, plane, pure-white; spores globose, smooth, hyaline, granular, 7–8 μ, rarely reaching 10 μ; stipe white, hygrophanous, smooth, glabrous, hollow, ventricose or enlarged below, 6–10 cm. long, reaching 3 cm. thick.

Type collected on the ground in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 659.*

Melanoleuca subpessundata sp. nov.

Pileus becoming plane or slightly depressed, usually with a conic or rounded umbo, gregarious, reaching 6.5 cm. broad; surface dry or slightly viscid, subglabrous, latericious, bay on the umbo, usually smooth, varying at times to radiate-rimose and imbricate-squamulose except on the umbo; context with a farinaceous odor and taste; lamellae sinuate, usually with a decurrent tooth, ventricose, broad, not crowded, pale-rosy-isabelline, the edges often notched; spores globose, smooth, hyaline, with granular contents, 6–7 μ; stipe slender, equal or enlarged below, smooth, pale-rosy-isabelline, glabrous above, decorated below with scattered, latericious fibrils, fleshy, solid or hollow, 7–9 cm. long, 7–10 mm. thick.

Type collected in soil in woods at Glen Brook, Oregon, November 7, 1911, *W. A. Murrill 733.* Also collected in similar situations at Mill City, Oregon, November 9, 1911, *W. A. Murrill 810;* near Corvallis, Oregon, November 6–11, 1911, *W. A. Murrill 1002;* and near Searsville Lake, California, December 11, 1911, *James McMurphy 122.* This species suggests *T. pessundatum* in its coloring, but the stipe is much longer and the spores are wholly different.

Melanoleuca subvelata sp. nov.

Pileus convex-conic when young, not fully expanding, loosely clustered; surface smooth, glabrous, moist but not viscid, latericious, leaving a stain on paper, margin entire, strongly inflexed, concolorous or somewhat paler; lamellae sinuate-adnate to adnexed, not crowded, broad, ventricose, pallid; spores ovoid, smooth, hyaline, uninucleate, 5–7 × 2.5–4.5 μ; stipe subequal to slightly ventricose, rosy, smooth and glabrous at the apex, fibrillose-shaggy near the center, fleshy, solid, 7 cm. long, about 1 cm. thick; veil scanty, fibrillose, rosy, evanescent, persisting as fibrils on the margin and stipe.

Type collected among humus under a log in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 567*. This species has a slight, rosy, fibrillose veil in young stages.

Melanoleuca tenuipes sp. nov.

Pileus small, thin, convex, not expanding, becoming very slightly depressed at the center, 2 cm. broad; surface pallid, with a stramineous or avellaneous tint, smooth, glabrous, margin entire, concolorous, incurved; lamellae sinuate-adnexed, distant, broad, several times inserted, white, more or less notched on the edge; spores ellipsoid, smooth, hyaline, 5–7 × 3.5–4.5 μ; stipe slender, equal, solid, concolorous, white at the apex, smooth, dry, glabrous, 4 cm. long, 2 mm. thick.

Type collected on the ground in woods near Seattle, Washington, October 20–November 1, 1911, *W. A. Murrill 536*. Also collected in the same locality, *W. A. Murrill 301*.

NEW COMBINATIONS

MELANOLEUCA ANOMALA	= Tricholoma anomalum
MELANOLEUCA ARENICOLA	= Tricholoma arenicola
MELANOLEUCA AVELLANEA	= Tricholoma avellaneum
MELANOLEUCA AVELLANEIFOLIA	= Tricholoma avellaneifolium
MELANOLEUCA BICOLOR	= Tricholoma bicolor
MELANOLEUCA CALIFORNICA	= Tricholoma californicum
MELANOLEUCA COLLYBIIFORMIS	= Tricholoma collybiiforme
MELANOLEUCA DRYOPHILA	= Tricholoma dryophilum
MELANOLEUCA FARINACEA	= Tricholoma farinaceum
MELANOLEUCA HARPERI	= Tricholoma Harperi
MELANOLEUCA NUCIOLENS	= Tricholoma nuciolens
MELANOLEUCA OLESONII	= Tricholoma Olesonii
MELANOLEUCA OREADES	= Tricholoma oreades
MELANOLEUCA PINICOLA	= Tricholoma pinicola
MELANOLEUCA PLATYPHYLLA	= Tricholoma platyphyllum
MELANOLEUCA PORTOLENSIS	= Tricholoma portolense
MELANOLEUCA RUDERICOLA	= Tricholoma rudericola
MELANOLEUCA ROSEIBRUNNEA	= Tricholoma roseibrunneum
MELANOLEUCA SECEDIFOLIA	= Tricholoma secedifolium
MELANOLEUCA STRIATELLA	= Tricholoma striatellum
MELANOLEUCA SUBLURIDA	= Tricholoma subluridum
MELANOLEUCA SUBMULTICEPS	= Tricholoma submulticeps
MELANOLEUCA SUBPESSUNDATA	= Tricholoma subpessundatum
MELANOLEUCA SUBVELATA	= Tricholoma subvelatum
MELANOLEUCA TENUIPES	= Tricholoma tenuipes

NEW YORK BOTANICAL GARDEN.

TOXICOLOGICAL STUDIES ON THE MUSHROOMS CLITOCYBE ILLUDENS AND INOCYBE INFIDA

Ernest D. Clark and Clayton S. Smith

With Plate 91

Introduction

It had already become evident from our earlier observations that *Inocybe infida* must be considered a poisonous mushroom, both when judged by its effects on man after ingestion[1] and also from its action when injected into frogs.[2] Both the clinical data from the reported cases of poisoning and our own experimental results indicated a poison of the general type represented by the muscarin of the fatal *Amanita muscaria*. However, the usual symptoms were not produced in frogs receiving injections of the poison in *Inocybe infida*. As is the case with muscarin, the *Inocybe* poison acted more particularly upon the nervous system and seemed to be similar to the narcotic poison found by Ford[3] in the closely related *Inocybe infelix*. A more detailed study of the action of *Inocybe infida* and certain other fungi upon the *exposed heart* appeared to be desirable and in this paper we present the results of such experiments.

Increased interest in this work was stimulated by the very many fatalities, in the fall of 1911, which were caused by eating poisonous mushrooms. After the autumn rains in September of that year, the newspapers of the temperate zone of this continent and Europe contained many notices of death from this cause. In one period of ten days there were *twenty-two* such deaths in the vicinity of New York City. In scarcely a single fatal case was

[1] Murrill. A New Poisonous Mushroom. Mycologia 1: 211. 1909.

[2] Clark and Kantor. Toxicological Experiments With Some of the Higher Fungi. Mycologia 3: 175–88. 1911.

[3] Ford. Distribution of Haemolysins, Agglutinins and Poisons in Fungi, etc. Jour. Pharmacol. and Exp. Therapeutics 2: 285–318. 1911.

the identity of the fungi definitely established by a mycologist but usually the cause seemed to be either *Amanita phalloides* or *A. muscaria;* twin sisters of death, known and feared from antiquity. Many newspaper clippings from several states and countries indicate that the accidents often resulted from mistaking *Amanita phalloides* for *Agaricus campestris,* the common cultivated "mushroom," and *Amanita muscaria* for *A. caesaria,* much appreciated by a Caesar and later by somewhat reckless epicures. We have been concerned only with the less common and striking species such as *Inocybe* and *Clitocybe* but it is very desirable that all fungi having poisonous properties should be so designated and always treated with caution. With the exception of the pioneer work of Ford very little chemical and toxicological study has been given to American mushrooms.

PREVIOUS TOXICOLOGICAL STUDIES ON CLITOCYBE AND INOCYBE

These two groups of fungi had not usually been regarded with suspicion as to their poisonous nature until various observers began to report unpleasant results following their consumption. Recently, specific charges of being poisonous have been brought against *Inocybe infida* by Murrill[1] and ourselves,[2] against *Inocybe infelix* by Ford,[3] against *Clitocybe dealbata sudorifica* by Ford and Sherrick,[4] and also against *Inocybe decipiens* by the same observers.[5] In *Clitocybe illudens* Ford[3] found a poison that was fatal to guinea-pigs but not to rabbits. As an edible fungus this plant has never been popular, possibly because its phosphorescent glow at night is not reassuring. Injection experiments with frogs showed that extracts of *Clitocybe multiceps* were harmless, as was expected. In the *Inocybe infida* we separated, by muscarin isolation methods, a water-soluble substance which, after injection into frogs, caused a prolonged state of paralysis often followed by complete recovery in a day or two. The aqueous extracts of *Inocybe infelix* prepared by Ford exerted

[4] Ford and Sherrick. On the Properties of Several Species of the Polyporaccae and of a New Clitocybe, etc. Jour. Pharmacol. and Exp. Therapeutics 2: 549–58. 1911.

[5] Ford and Sherrick. Further Observations on Fungi, etc. Jour. Pharmacol. and Exp. Therapeutics 4: 321–32. 1913.

a powerful narcotic effect on the nervous system of rabbits and guinea-pigs, described as a profound depression lasting for hours, sometimes with complete recovery. It is evident that these two *Inocybes* contain poisonous material acting as a strong narcotic agent but not necessarily causing death. Muscarin itself does not produce the symptoms already described and the mixed poisons of *Amanita muscaria* give still another series of effects upon the organism. It is believed by many investigators that muscarin *alone* is not responsible for all of the fatal effects following ingestion of *Amanita muscaria*. Both in clinical work and in animal experiments one finds that although atropin is an antidote for *pure* muscarin it does not wholly neutralize the toxic action of *A. muscaria*. Some of our experiments indicate that muscarin may be present in other fungi like *Inocybe* and *Clitocybe* whose effects are neutralized by atropin while this was not wholly true of our extracts of *Amanita muscaria*.

EXPERIMENTAL PART

Description of Botanical Material.—All of the fungi used by us were identified and labelled for us by Dr. Murrill. Our large lot of *Clitocybe illudens* was collected near the New York Botanical Garden in the summer of 1911. The *Inocybe infida* material was also collected during the summer of 1911 on the lawns of the New York Botanical Garden. We used *Amanita muscaria* that came from Rochdale, Massachusetts, in August, 1911. Dried plants of species of *Clitocybe* and *Amanita* are large and easily handled while those of *Inocybe* are very small after desiccation and usually five or more did not weigh more than one gram. The dry fungi were ground repeatedly in a coffee-mill until a very fine powder was obtained. This powder was weighed and extracted as described below.

Description of Chemical Methods Employed.—The powdered fungi were extracted twice for twenty-four hour periods, at room temperature, with ten times their weight of 95 per cent. alcohol. The alcoholic extracts were carefully evaporated to a thick syrup which was in turn extracted with several 10 c.c. portions of alcohol. These repeated alcohol extractions and subsequent evaporations were continued until practically all of the fats, sugars and

gums had been eliminated. A final extract of the last thick syrup was made with absolute alcohol and, after this had been evaporated, the syrupy residue was mixed with powdered glass and dried in a vacuum desiccator until a yellowish, friable mass resulted. This powder was extracted with a small volume of absolute alcohol, the latter was removed from the extract by evaporation, and the small amount of yellowish waxy residue was taken up in physiological saline solution after which the traces of insoluble matter were removed by filtration. Unless otherwise noted this solution of the toxic material was used for injection or for experiments with the exposed hearts. In order to separate and purify any toxic alkaloidal material we took up the last residue from absolute alcohol with water, added a little dilute sulphuric acid and finally a solution of potassio-mercuric iodid until no more of the yellow granular precipitate formed. The details of the chemical treatment of this substance, precipitated by the potassio-mercuric iodid, may be found in our earlier paper.[6] At the final stage of this treatment the small amount of poisonous water-soluble material was dissolved in physiological salt solution and then used for the toxicological experiments. This process of alcohol extraction and alkaloidal purification was originally planned to isolate muscarin from *Amanita muscaria;* we found it to be adequate for this purpose. We also found that this same process would separate and concentrate the toxic material in *Inocybe infida* and *Clitocybe illudens.* Chemically, then, the poison in the latter forms seemed to belong to the muscarin type but that question could finally be decided only by experiments on animals.

TOXICOLOGICAL EXPERIMENTS WITH EXPOSED HEARTS

The hearts of medium-sized pithed frogs were exposed and connected in the usual way for the preparation of graphic records on a kymograph drum. In several cases the exposed hearts of turtles were used but with no appreciable difference in the type of records obtained. Solutions of the toxic material in physiological salt solution were always used on the hearts and in no case was the effect of an extract tested until we first obtained a

[6] Loc. cit.

normal tracing from the heart. The exposed hearts were kept moist with physiological saline solution and all traces of a previous test solution were washed away before adding an atropin solution, etc. To test the neutralizing effects of atropin we used a 0.5 per cent. solution of the sulphate salt of this alkaloid. Many tracings from different mushroom preparations were obtained but we shall only describe briefly and illustrate a few of the typical ones.

Experiments with Inocybe infida Extracts before Alkaloidal Purification

Experiment 6.—April 20, 1912. Weight of frog was 32 gm. After placing this solution on the heart the frequency and amplitude of the beats both decreased until a complete standstill was produced. This was overcome in a few seconds by flushing the heart with atropin solution.

Experiment 10.—May 22. The heart of a decerebrated turtle (weight 583 gm.) was exposed, treated with an *Inocybe* extract, and the effect studied. The extract in this case was much more concentrated than that used in Experiment 6 and with the turtle heart it caused a complete standstill in 5 seconds. This effect was neutralized by atropin in 10 seconds.

Experiment 4.—April 16. Weight of frog was 28 gm. The *Inocybe* extract used was the same as that in Experiment 6 and it showed the same characteristic action on this heart. See Plate 91, fig. 1.

Experiments with Inocybe infida Extracts after Alkaloidal Purification.

Some of the mushroom extracts were purified by the chemical process described and when these extracts were tested on frogs they were found to have retained their toxic properties unchanged or, more often, to have had them augmented. This would indicate that the toxic material is precipitated and purified by methods used for alkaloids and muscarin.

Experiment 24.—June 6. The frog weighed 36 gm. This purified extract was very active in causing a complete standstill

which was relieved in a few seconds by atropin. See Plate 91, fig. 2.

Experiments with the Ash of an Active Unpurified Inocybe Extract

Experiment 21.—May 29. About 15 c.c. of the extract used in Exp. 10 were evaporated to dryness and carefully ashed at low red heat, the ash was dissolved in water and tested on the heart of a frog weighing 29 gm. This solution did not produce the slightest flutter in the normal tracing and so it is evident that the inorganic or ash constituents of the fungus are not responsible for its toxic action.

Experiments with Unpurified Extracts of Amanita muscaria

Experiment 9.—May 22. The action of an *Amanita* extract was tested upon the heart of a frog weighing 33 gm. In this case a standstill of the heart was not caused although the usual retarding effect was noticed. This effect was partially neutralized by atropin.

Experiment 11.—May 23. Experiment 9 was repeated with a frog weighing 29 gm. The same slight muscarin effect appeared.

Experiments with Purified Extracts of Amanita muscaria

Experiment 26.—June 3. The action of a purified extract of this *Amanita* on a frog (weight 31 gm.) was similar to that recorded in Experiments 9 and 11 and it did not prove to be nearly as toxic as extracts of *Inocybe infida* or *Clitocybe illudens.*

Experiments with Unpurified Extracts of Clitocybe illudens

Experiment 5.—April 16. Frog weighed 35 gm. The heart was soon brought to a standstill but was started at once by atropin. The action was exactly the same as that of *Inocybe infida* but it did not take place as rapidly. See Plate 91, fig. 3.

Experiment 14.—May 23. Turtle weighed 633 gm. The turtle's isolated heart reacted to *Clitocybe* extract in a way difficult to distinguish from the response to the *Inocybe* extract.

Experiments with Purified Clitocybe illudens Extracts

Experiment 33.—June 6. Frog weighed 28 gm. The action of this purified *Clitocybe* preparation was the same as that of the unpurified extracts.

Experiments with the Harmless Clitocybe multiceps Extracts

Experiment 20.—May 29. As a control on our processes we tested the unpurified extract of this fungus on the heart of a frog (weight 33 gm.). It was found to be entirely without action. Evidently we had not been producing toxic effects through our procedures.

TOXICOLOGICAL EXPERIMENTS ON FROGS

In order to study the effect of the various fungi upon animal organisms as a whole we made injections of the different preparations into the dorsal lymph-sacs of frogs. The extracts were portions of those that were used in the exposed heart experiments; their preparation has already been described. Typical experiments with the different mushroom extracts will be given in order to show the characteristic action of each species.

Experiments with Purified and Unpurified Extracts of Amanita muscaria

Experiment 30. June 3, 1912. Frog 11 weighed 24 gm. Received an injection of 1 c.c. of *purified* extract at 5.47 P.M.

5.49 P.M. Partly paralyzed.
5.52 P.M. Wholly paralyzed.
5.56 P.M. Heart stopped.
5.58 P.M. Received injection of 1 c.c. atropin solution.
6.03 P.M. Heart begins to beat weakly and irregularly.
June 4, 9.15 A.M. Frog 11 found dead.

The results of parallel experiments with *unpurified Amanita* extracts differed in no way from those indicated above.

Experiments with Purified Extracts of Inocybe infida

Experiment 28.—June 3. Frog 8 weighed 23 gm. Received injection of 1 c.c. of this extract at 3.46 P.M.

3.48 P.M. Partly paralyzed.

3.49 P.M. Wholly paralyzed.
3.51 P.M. Heart at a standstill.
3.53 P.M. Received injection of 1 c.c. atropin solution.
3.56 P.M. Heart begins to beat slowly and it gradually resumes its normal action.
5.45 P.M. Frog 8 appears normal.

While this frog was wholly paralyzed we bared the sciatic nerve and, upon stimulation with an induced current, we obtained a normal response, thus indicating that no curare effect was present. Other experiments with *Inocybe* material gave similar results. In some cases the frogs died before the next morning; and in others, recovery seemed to be complete.

Experiments with Purified and Unpurified Extracts of Clitocybe illudens

Experiment 13. May 23. Frog 3 weighed 28 gm. Received injection of 1.5 c.c. of *unpurified* extract at 5.24 P.M.
5.28 P.M. Paralyzed.
5.33 P.M. Heart at standstill.
5.38 P.M. Tested as above indicated; there was no curare effect.

Experiment 27. May 27. Frog 9 weighed 36 gm. Received injection of 1.5 c.c. of *purified Clitocybe* extract at 12.25 P.M.
12.30 P.M. Lethargic.
12.40 P.M. Paralyzed; heart at standstill.
12.42 P.M. Received injection of 1 c.c. atropin solution.
12.50 P.M. Heart beats irregularly.
5.30 P.M. Frog 9 found dead.

CONCLUSIONS

It is evident that both *Clitocybe illudens* and *Inocybe infida* contain material exerting a characteristic muscarin effect when tested upon the exposed hearts of frogs and turtles. Furthermore, this toxic action on the exposed heart is completely overcome by the application of atropin sulphate solutions; an action analogous to that with a *pure* muscarin preparation. For some reason, parallel experiments with extracts of *Amanita muscaria*

extracts did not show the expected toxic effects nor were the latter wholly neutralized by atropin. This may be explained by assuming that this *Amanita* contains another toxic substance as well as muscarin. In fact, this theory has been advanced by other investigators to account for the results of their clinical observations and animal experiments. The lot of *Amanita muscaria* used in this work did not cause the acute muscarin symptoms which were expected from the experiments in our earlier paper. It is interesting to note that this last lot of the *Amanita* was collected in a different state and at a different time, thus giving an opportunity for both the seasonal and local variations in toxicity reported by others.

Injection experiments with *Clitocybe illudens* and *Inocybe infida* confirmed the results obtained with the isolated hearts. The toxicological evidence of all our experiments points toward muscarin as the poison in *Inocybe infida* and *Clitocybe illudens,* and this idea gains further confirmation from the fact that our methods of extraction and purification were those originally suggested for the isolation of muscarin and alkaloidal substances from fungi. Parallel experiments with the edible *Clitocybe multiceps* revealed no toxicity of any sort. The ash constituents of *Clitocybe illudens* are not responsible for its toxicity. It was necessary to test this point because it has been stated that salts of potassium produce a muscarin-like effect on the heart.[7] From our studies on *Clitocybe illudens* and *Inocybe infida* it is plain that these plants should not be eaten, since all of them contain material having a dangerous action upon the nervous system.

We wish to thank Prof. Wm. J. Gies and Prof. F. S. Lee, of the College of Physicians and Surgeons, for much helpful advice. Dr. W. A. Murrill suggested this study of poisonous fungi and our thanks are also due him for providing and identifying most of the material used.

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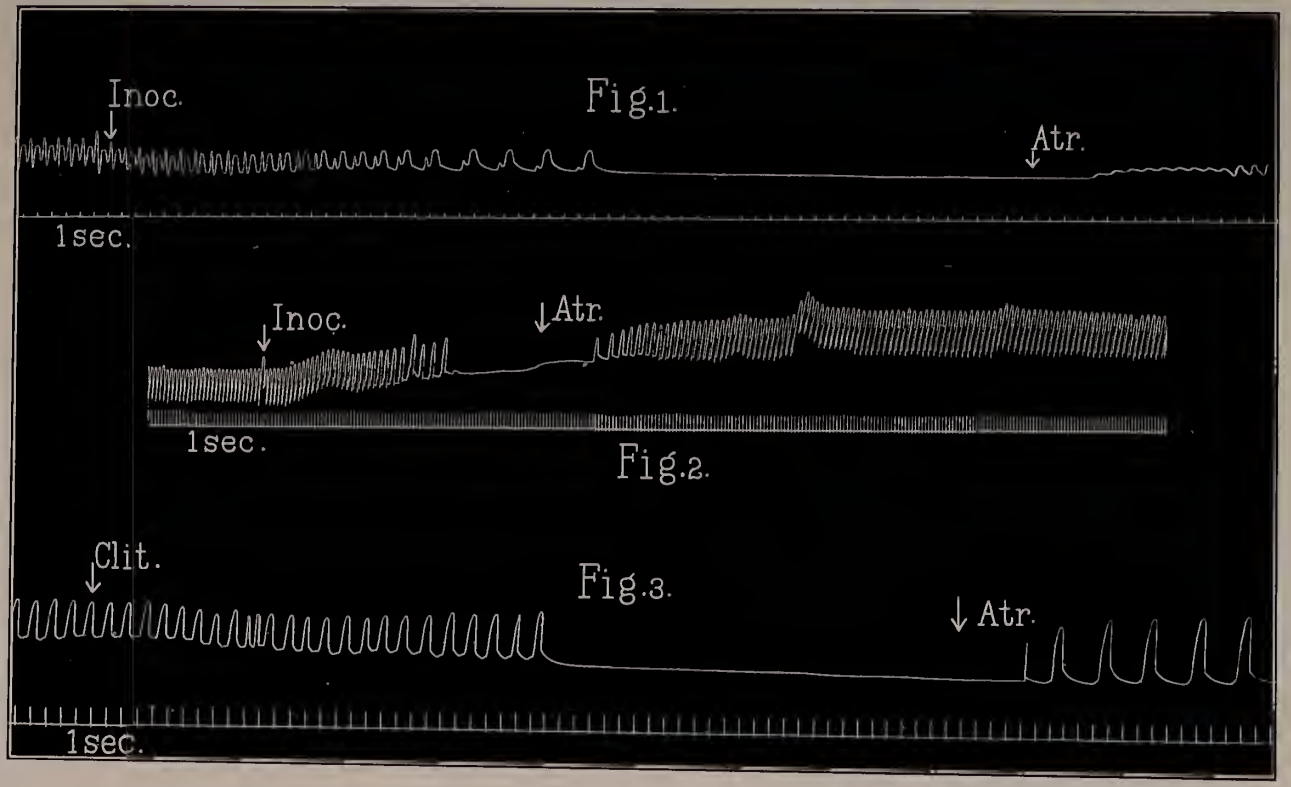
[7] Führner. Nachweis und Bestimmung von Giften auf biologischen Wege. Abderhalden's Handbuch d. Biochem. Arbeitsmethoden, V, (I), p. 77. 1912.



Graphic records of effect of mushroom extracts on frog hearts. The arrows indicate time when the various mushroom extracts and atropin solution were applied to the exposed heart

FURTHER CULTURES OF HETEROECIOUS RUSTS[1]

W. P. Fraser

Field observations extending over several years, and culture experiments during the spring of 1911, furnished evidence that the fern rusts of the genus *Uredinopsis* are heteroecious, and have their aecia on *Abies balsamea;* these aecia being the white-spored forms that have passed as *Peridermium balsameum* Peck. The infection experiments during 1911 were inconclusive, so further experiments which are described in the following pages were undertaken in 1912 to establish if possible the connection of these forms.

The teliosporic material used in all the experiments was collected near Pictou, N. S., and was wintered in the open in small cheese-cloth bags; but the culture experiments with this material were carried on in the greenhouse of Macdonald College. The plants of *Tsuga* and *Abies* used in the experiments were obtained not far distant from the college. They were taken into the greenhouse in early spring, as soon as the frost was out of the ground, and kept in the greenhouse till the young leaves appeared and the plants were in the proper stage for infection. As *Peridermium balsameum* was never collected in the field within several miles of where the plants used in these experiments were obtained, and as a number of trees of *Tsuga* and *Abies* obtained at the same time and place were kept as checks, and all remained free from infection, there seems to be no reasonable doubt that the trees used in the experiments were free from outside infection.

The writer returned to Nova Scotia about the middle of June, and the experiments with aeciosporic material were carried on in the laboratories of Pictou Academy. The ferns used in these experiments at Pictou were obtained a week or two before the ex-

[1] Read before the American Phytopathological Society at the Cleveland meeting, Dec. 31, 1912.

periments were performed. They were selected from a place remote from any known or suspected source of infection and in all cases, as described in the experiments, a number of checks were kept. The writer was thoroughly familiar with the locality, and no fern rust appeared until some weeks after the ferns were obtained, nor did any appear later on the plants surrounding those that had been selected for the experiments.

The aeciosporic material was all collected near Pictou. At the time of collection no uredinia had developed on the ferns near the trees from which it was collected or anywhere in the vicinity.

The ferns used in the experiments with the aeciosporic material were sprayed with water by means of an atomizer. The aeciospores were then shaken from the shoots on the under side of the leaves of the ferns. The shoots bearing aecia were also suspended above the ferns, and the whole was covered with a belljar for a day or two. This was done in a room separate from where the cultures and checks were kept.

The writer is indebted to Mr. E. M. Duporte and Mr. P. I. Bryce, assistants in the department, for the care of the cultures at Macdonald College during his absence, also to the Commissioners and Dr. R. Maclellan, of Pictou Academy, who in their generous way freely placed the laboratories of that institution at his disposal.

UREDINOPSIS STRUTHIOPTERIDIS Störmer

Teliosporic material of this rust on *Onoclea Struthiopteris* (L.) Hoffm. was suspended above a small plant of *Abies balsamea* (L.) Mill. on May 13. Pycnia were noticed on May 27 which probably appeared earlier, and aecia began to appear on June 1, both in great abundance, practically every leaf of the young shoots being infected. Another sowing in a similar manner on May 28 gave pycnia on June 9, with aecia showing by June 18.

Fresh aeciospores of *Peridermium balsameum* on *Abies balsamea* (L.) Mill., which were collected beside ferns of *Onoclea Struthiopteris* that were badly rusted the previous season, were sown on *Onoclea Struthiopteris, O. sensibilis* L., *Phegopteris Dryopteris* (L.) Fee and *Osmunda Claytoniana* L. on June 27.

Uredinia of *Uredinopsis Struthiopteridis* appeared on *Onoclea Struthiopteris* in abundance on June 6. The spores were oozing out on June 8. The other ferns remained free from infection. Another sowing of a collection also believed from field observation to be connected with *Uredinopsis Struthiopteridis* was made on *Onoclea Struthiopteris* and *Phegopteris Dryopteris* on June 29, with uredinia rather abundant on July 8 on the former and no infection on the latter. A third sowing of a collection similar to the others on *Onoclea Struthiopteris* and *Osmunda Claytoniana* on July 2 produced very abundant infection on *Onoclea Struthiopteris,* the uredinia appearing on July 8. Teliospores were present on July 30. *Osmunda Claytoniana* was not infected. Five pots of *Onoclea Struthiopteris* obtained at the same place and at the same time as those used in the experiments were kept as checks and remained entirely free from infection.

The place where the aeciosporic material was collected was kept under observation, and about a fortnight after the spores of *Peridermium balsameum* were being shed, the ferns of *Onoclea Struthiopteris* which grew immediately beside showed the uredinia of the rust in abundance. The distribution of the uredinia was such that it indicated the *Peridermium* on *Abies* as the source of infection.

UREDINOPSIS OSMUNDAE Magn.

Teliosporic material of this rust on *Osmunda Claytoniana* L. was placed in a moist chamber, and the teliospores germinated freely in a few days. The leaves bearing the germinating telia were then suspended above plants of *Abies balsamea* on May 26. Pycnia were observed on June 10, and aecia on June 18. Five more sowings were made and in all cases the pycnia and aecia of *Peridermium balsameum* followed. In several cases the germinating teliosporic material was placed immediately above the young shoots of *Abies* and these showed marked infection, while the other shoots remained practically free.

Observations in the field strengthened the results of the cultures. Whenever the writer found a very abundant development of the uredinia of this rust on *Osmunda* in early summer it was beneath, or close by, trees of *Abies balsamea* that showed a rich

infection of *Peridermium balsameum*. The distribution of the aecia on the trees indicated that infection had come from the rusted ferns of the previous season. These observations were made in a number of places.

UREDINOPSIS ATKINSONII Magn.

Aeciospores of *Peridermium balsameum* from *Abies balsamea* which seemed from field evidence to be connected with this rust on *Aspidium Thelypteris* Sw. were sown on a pot of these ferns on July 1, but without infection. Another sowing on July 3 of similar material gave uredinia which appeared on July 10, but not in great abundance. Three pots of *Aspidium Thelypteris* were kept as checks and remained free from infection. There was some field evidence of the connection of these forms but it was not very pronounced.

UREDINOPSIS PHEGOPTERIDIS Arthur

Teliosporic material of this rust on *Phegopteris Dryopteris* (L.) Fée was suspended in the usual way above *Abies balsamea* on May 27. Pycnia appeared on June 12 followed by aecia. Infection was not marked, only about twenty of the young leaves bearing aecia. Observations in the field also indicated the connection of these forms.

UREDINOPSIS MIRABILIS Magn.

Teliosporic material of this rust on *Onoclea sensibilis* L. was suspended above *Abies balsamea* (L) Mill. on May 13. Pycnia and aecia followed, the latter being first noticed on June 6, about a dozen leaves showing aecia.

Aeciospores (*Peridermium balsameum*) from *Abies balsamea* were sown on two pots of *Onoclea sensibilis* on June 28. Abundant uredinia followed, being first noticed on July 5, the urediniospores were oozing out by July 8.

Another sowing of aeciospores was made on *Onoclea sensibilis, Onoclea Struthiopteris* and *Aspidium Thelypteris* on July 1. Abundant infection of the pot of *Onoclea sensibilis* followed, the uredinia being present on July 8. None of the other ferns showed infection.

Another sowing on *Onoclea sensibilis* on July 3 also gave abundant infection, the uredinia appearing by July 10. Five pots of plants from the same place as those used in the experiments and obtained at the same time were kept as checks and showed no infection.

Observations in the field strengthened the evidence of connection furnished by the cultures. It was noticed for several years that wherever this rust was common on *Onoclea* in the following spring the firs near were abundantly infected with *Peridermium balsameum,* but the sequence of spore forms was not carefully observed. This season several places, where this rust was known to be common on *Onoclea sensibilis* in 1911, were kept under observation. It was found that *Peridermium balsameum* appeared abundantly on the trees of *Abies balsamea* that grew near about June 25. In about ten days uredinia appeared on the ferns of *Onoclea sensibilis* growing immediately beneath, and soon became common.

The experiments and field observations here described seem to the writer to establish the connection of the five species of *Uredinopsis* used in the experiments with the white-spored aecia on *Abies balsamea* which have passed as *Peridermium balsameum.* The question whether these are distinct species with similar aecia or whether they should be included under one species needs further study. It will be noticed that the evidence of cultures, as far as it goes, indicates that the species established are good.

The examination of the cultures and collections of the fern rusts of the genus *Uredinopsis* convinced the writer that the first spore form to appear is the urediniospore. The spores which have been regarded as aeciospores were rarely present in the collections and never appeared first.

In the genus *Hyalopsora* the aeciospores were found to be the first to appear.

PUCCINIASTRUM MYRTILLI (Schum.) Arthur

Teliosporic material of this rust on the leaves of *Vaccinium canadense* Kalm. was suspended on May 28 above a young tree of *Tsuga canadensis* (L.) Carr. Pycnia were observed on a number of leaves on June 10, and aecia began to appear on June

14. The aecia developed rapidly on about fifty of the leaves, and were mature in a few days. The aecia were the deep reddish-yellow form collected abundantly in Nova Scotia in several regions beside *Pucciniastrum Myrtilli* on *Vaccinium canadense* and *V. pennsylvanicum* Lam. which has passed as *Peridermium Peckii* Thüm. but which Arthur regards as distinct.[2]

This confirms the life history of this species as established by Clinton (Report Conn. Agric. Exper. Sta. 1909–1910, p. 719 and MS.) who sowed aeciospores from *Tsuga canadensis* on *Gaylussacia baccata* (Wang) C. Koch. and produced the uredinia of *Pucciniastrum Myrtilli.*

MELAMPSORA MEDUSAE Thüm.

Leaves of *Populus grandidentata* Michx. bearing abundant telia of this rust were placed in a moist chamber and the teliospores gave excellent germination in a few days. A sowing on two plants of *Tsuga canadensis* (L.) Carr. was followed on both plants by pycnia in about a week, and later by aecia.

On July 18, 1912, the cones of a considerable area near Pictou were found to be infected by *Caeoma Abietis-canadensis* Farl., about one half of the cones showing infection. The place was visited about ten days later and the uredinia of *Melampsora Medusae* were abundant on the leaves of *Populus grandidentata* which grew near and beneath the infected trees. These experiments and observations confirm the cultures of last year.[3]

MELAMPSORA ARCTICA Rostr.

Teliosporic material from *Salix* (species undetermined) was placed in a moist chamber until the teliospores germinated when it was suspended above *Abies balsamea* on June 10. Pycnia were noticed on June 24 followed by aecia. This experiment confirms the cultures of the previous season.[4]

[2] See Mycologia 4: 184. 1912.
[3] See Mycologia 4: 188. 1912.
[4] See Mycologia 4: 187. 1912.

SUMMARY OF CULTURES DESCRIBED IN THIS ARTICLE

1. Life histories established for the first time.

Uredinopsis Struthiopteridis Störmer. Two successful sowings of teliospores from *Onoclea Struthiopteris* (L.) Hoffm. on *Abies balsamea* (L.) Mill. Three successful sowings of aeciospores from *Abies balsamea* on *Onoclea Struthiopteris.*

Uredinopsis Osmundae Magn. Six successful sowings of teliospores from *Osmunda Claytoniana* L. on *Abies balsamea.*

Uredinopsis Atkinsonii Magn. Aeciospores from *Abies balsamea* infected *Aspidium Thelypteris* Sw.

Uredinopsis Phegopteridis Arthur. *Teliospores* from *Phegopteris Dryopteris* (L.) Fee infected *Abies balsamea.*

Uredinopsis mirabilis Magn. Teliospores from *Onoclea sensibilis* L. infected *Abies balsamea.* Three successful sowings of aeciospores from *Abies balsamea* on *Onoclea sensibilis.*

2. Life histories supplementing previous work.

Pucciniastrum Myrtilli (Schum.) Arthur. Teliospores from *Vaccinium canadense* Kalm. infected *Tsuga canadense* (L.) Carr.

Melampsora Medusae Thüm. Teliospores from *Populus grandidentata* Michx. infected *Tsuga canadensis* (L.) Carr.

Melampsora arctica Rostr. Teliospores from *Salix* infected *Abies balsamea* (L.) Mill.

MACDONALD COLLEGE,
PROVINCE OF QUEBEC, CANADA.

UREDINALES ON CAREX IN NORTH AMERICA

J. C. Arthur

In the systematic work on Uredinales in the North American Flora, a monographic treatise, every entry is based upon a collection in the author's herbarium, either an original one, or some data to represent a collection in another herbarium. Whatever advantage in fundamental accuracy is secured in this work probably depends largely upon the application of four tests which are the foremost guides used in systematically placing every collection: (1) life cycle, so far as direct or collateral evidence can be found; (2) name and systematic position of host; (3) microscopic characters of sorus and spores; (4) the limitation of a species in view of the influence of host and possible occurrence of races.

It has not been many years since most collections of *Carex* rusts were largely labelled "*Puccinia Caricis*" or "*P. caricina*" and said to be on "some species of sedge," or on "*Carex* sp.," and with such material the work on the North American Flora began.

As to the first test to be applied to each collection, regarding the life cycle, *Carex* rusts may be assumed to be uniform in having their spore forms of the general character of those of *Puccinia graminis* and in being heteroecious.

As to the second test, regarding the host, slow but steadily increasing progress has been made in securing authentic determination of the hosts. All *Carex* rusts belong either to the genus *Nigredo* (having 1-celled teliospores) or *Dicaeoma* (having 2-celled teliospores). The material for the species under *Nigredo*, published about a year ago, consisted of 21 collections with leaves and stems only, and 35 other collections accompanied by more or less perfect fruiting parts. The determinations of the latter had been verified or completed by comparison with the

author's phanerogamic herbarium, although a few collections had been submitted to experts.

The *Carex* material for the genus *Dicaeoma* is now being studied. A few specimens from time to time have been sent to Dr. Theo. Holm, of Washington, D. C., for critical decision regarding the host. Feeling the great advantage in accuracy that would accrue from having all the material examined and compared under the most favorable conditions, the very generous permission of Dr. Holm to submit the full set to him was accepted, and in June, 1912, all the material being used as the basis for the study of the genus *Dicaeoma,* together with that previously used for the genus *Nigredo,* was sent, to which was added the phanerogamic set of *Carex.*

The phanerogamic collection is used as a basis of comparison, in order to detect any lapses from a probably correct naming of the host. It contains a total of 321 sheets and 133 species, wholly from North America, and includes the Olney and Bailey exsiccatae. Some of the specimens were determined by Wm. Boott and L. H. Bailey, and the Iowa material was once examined by R. I. Cratty. It is gratifying to note that Dr. Holm found occasion to change the names of only five species (nine specimens) of this phanerogamic set, all being changes to closely allied species which some authors consider segregates.

The examination and study of the mycological material was a far greater tax upon Dr. Holm's time and patience, not only because of its fragmentary condition but because the opening of mycological packets in large numbers is burdensome.

Of the material submitted, now being used for the genus *Dicaeoma,* there were 645 packets which contained no fruiting parts of the host, and such names as collectors have attached to them cannot be verified. Of these, however, Dr. Holm questions the correctness of 32, either because of the appearance of the leaves, or because the locality is outside the known range of the species.

Of the 405 packets submitted, which contained some fruiting parts of the host, the larger portion had the specific name of the host attached. From a study of this material Dr. Holm found it

necessary to change the names on 29 packets. Out of the 52 packets on which the species of the host had not been given, Dr. Holm was able to supply 34 determinations.

Altogether Dr. Holm examined 1050 packets now being used for the systematic work under the genus *Dicaeoma,* and 56 packets for that previously used under *Nigredo,* or a total of 1106. For this important and authoritative assistance in trying to render the NORTH AMERICAN FLORA as accurate as possible the writer desires to publicly extend to Dr. Holm most hearty thanks.

In the preliminary manuscript for the next rust number of the NORTH AMERICAN FLORA at the present writing (February 1, 1913) there are recognized 24 species of *Dicaeoma* occurring upon 106 species of *Carex.* These 24 species are represented by 1200 North American collections, 150 collections having been added since the material was returned by Dr. Holm in November last. Although this seems like a vast array of material for the rusts on a single genus of hosts, yet one half of the 24 species are represented by 13 or less collections each, and four by only one or two collections each, these four species being from readily accessible localities in Delaware, West Virginia, Wisconsin and South Dakota, except one which is from Guatemala. Some stress should be laid upon this situation as indicating the desirability that collectors search for *Carex* rusts more assiduously, especially for such as appear to be associated in the field with definite heteroecious aecia, and not follow the practice of a famous mycologist of a prominent university who once confessed that he usually threw away *Carex* rusts—they were so troublesome to name.

It is to be hoped that no one will be discouraged by the fact that the chances are not many for picking up one of these rarer species, taking the comparative number of collections under each species as an indication. The three most commonly collected species are one with aecia on *Aster, Solidago, Erigeron* and similar genera, now passing under several names, which is represented by 208 collections, one with aecia on *Urtica* represented by 152 collections, and one with aecia on *Ribes* represented by 146 collections. The remaining seven large species range from 86 to 18 collections each.

As this paper is intended to deal chiefly with the *Carex* hosts, nothing has been said about aecial hosts of the 24 species involved, but incidentally it may be stated that aecia belonging to 11 of these species are known, and are represented by 676 collections at the present time, for which it is hoped to secure equal accuracy in determinations by enlisting the aid of specialists.

So much as to the second test used in the rust work for the NORTH AMERICAN FLORA, the one regarding hosts, and we now turn to the third test, the one relating to microscopic characters of the fungus. It being difficult to carry in mind the minute appearance of the spores for purposes of critical comparison, as many of the collections as possible have been illustrated by camera lucida drawings made with a uniform amplification of 625 diameters. There have been 693 of the *Dicaeoma* collections on *Carex* illustrated in this way, giving 1029 individual teliospores, 937 urediniospores and 69 amphispores; while of their aecial connections 174 collections have been similarly illustrated, showing 135 individual aeciospores and 86 peridial cells, with 17 sections of pycnia more or less completely drawn.

Many of the collections have had sets of data taken regarding length and breadth of a number of spores, usually six to eight, thickness of apex, side wall and pedicel, the color, sculpturing of surface, and number and position of pores. With the *Carex* collections for *Dicaeoma* are 355 such sets of data, and with the associated aecial collections 90 similar sets of data, extended to include peridial cells and pycnia.

Regarding the fourth test applied to each collection, that of the limital characters for the species, nothing need be given in this connection, as the purpose of this article is especially to call attention to the material being used for study. It may be interjected, however, that the term species in the manuscript for the final work is generally made to include such varieties, races or physiological species as many authors prefer to distinguish by separate names.

The presentation of the above statistics will illustrate some features of the method employed in preparing the manuscript for the rust part of the NORTH AMERICAN FLORA, as other collec-

tions are treated in essentially the same way as those on *Carex*. It may also indicate to collectors the desirability of including in rust collections such parts of the hosts as best serve to permit of their independent verification or determination. Possibly some idea may be gleaned of the labor and time which such a work entails. As the completeness of the work rests upon the availability of material, it is hoped that in the interests of mycologists in general those who possess either recent or old collections of rusts may contribute duplicate sets when convenient to do so.

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NOTES ON NEW SPECIES OF FUNGI FROM VARIOUS LOCALITIES

Charles E. Fairman

1. **Pestalotia truncata septoriana** var. nov.

Supposed to be the foliicolous form of a fungus generally found on wood (*Fagus,* Corda), branches (*Populus fastigiata,* Léveillé) or on stems (*Rubus,* as var. *Rubi* Karst.)[2] Regarding the spelling of the generic name it may be noted that the genus was published by DeNotaris[2] as *Pestalotia.* I do not know who first varied the spelling nor for what reason the change was made. I suggested to Dr. Barnhart, librarian of the New York Botanical Garden, that it might have been for euphony but he gave it as his opinion, in a verbal communication, that *Pestalotia* was equally euphonious and to be preferred. Taking up the matter with Prof. Henry F. Burton, of the department of Latin in Rochester University, I obtained the following information: "Pestalotius is undoubtedly the correct Latin form for Pestalozzi. Classical Latin has no 'z' sound or 'z' character except in a few words borrowed from the Greek. The Italian 'z' or 'zz' often stands for Latin 't' or 'ti.' For example in Palazzo (palatium), Arezzo (Arretium), Firenze (Florentia), Venezia (Venetia)."

Spots circular, 1–4 mm. in diam., or irregular and 1–10 mm. in length, light-brown, surrounded by a narrow brown line, becoming paler and deciduous with age; acervuli epiphyllous, minute, punctiform, scattered and sparse, arranged like the pycnidia of some *Septoria;* spores oblong-clavate, 2–4 septate, as a rule not guttulate, not much constricted, intermediate cells dark, end cells hyaline, the upper cell broad and rounded from which protrude 2–3 cilia simple or branched, the lower cell more acute and ending in a filiform pedicel, 20–22 × 7–8 μ.

On leaves of a small shrub probably belonging to the Rubiaceae, Pueblo Viejo, Mexico, June, 1911, *Rev. H. Q. Morton.*

[1] Hedwigia. 1896, p. 48.
[2] Micr. Ital. Dec. II, p. 80.

2. **Septoria Carricerae** sp. nov.

Spots white above, brownish on the lower surface of the leaves; pycnidia minute, epiphyllous on oblong spots, scattered, black, smooth, centrally ostiolate, immersed then erumpent; spores filiform, straight or curved, acute at apices, about 3-septate, hyaline, 30–35 × 1.5–2 μ.

On leaves of *Oplismenus hirtellus* (L.) Roem. & Schult, a Mexican grass called Carricera, Pueblo Viejo, Mexico, June, 1911, *Rev. H. Q. Morton.*

3. **Sphaeropsis Coccolobae** sp. nov.

Pycnidia hypophyllous, on the midrib of the leaves, scattered, immersed then erumpent, causing round pustular elevations, through which protrude the minute black ostiola, surrounded by a few simple, straight, hyaline then purplish hairs or mycelial threads; spores hyaline at first then yellowish, on cylindric hyaline basidia, mostly obovate, at times rounded or ellipsoid, with rather thick walls and granular contents, 12–30 × 12–15 μ.

On leaves of "Uvas de la Playa," Beach Grapes, *Coccoloba uvifera,* Pueblo Viejo, Mexico, June, 1911, *Rev. H. Q. Morton.*

4. **Sphaeropsis rhodocarpa** sp. nov.

Pycnidia black, numerous, closely aggregated but not in a stroma, globose, immersed then erumpent, 150–180 μ in diam.; spores rounded, oblong or ellipsoid, rounded, at times with one end subacute, hence becoming somewhat ovate, often inaequilateral, with two large guttulae, hyaline then brown, 10–17 × 7–10 μ; basidia hyaline, cylindric, from 20 to 23 μ in length.

On fruits of Persian Yellow Rose, Lyndonville, N. Y., autumn of 1911, *C. E. Fairman. Phoma rhodocarpa* Sacc. is found on same habitat.

5. **Hendersonia hypocarpa** sp. nov.

Pycnidia minute, immersed then erumpent, with minute, slender, punctiform ostiola; spores oblong-ellipsoid to oblong-clavate, 3-septate, strongly constricted at the septa, light-brown, with conspicuous dark-brown lateral walls and septa, 10–17 × 5–7 μ.

On flower stems of Persian Yellow Rose, Lyndonville, N. Y., autumn, 1910, *C. E. Fairman.*

Differs from *Hendersonia Rosae* Kickx,[3] in smaller pycnidia, and in larger, more constricted spores, as compared with Myc. Germanica no. 420 on branches of *Rosa villosa*. Kickx, loc. cit. says "peritheces immerges, eparpilles autours des noeuds, soulevant l'epiderme qui devient bulbeux, blanc, ou noirci, par transparence et qui se dechire longitudinalement pour livrer passage a l'ostiole."

6. **Hendersonia coccolobina** sp. nov.

Leaf spots irregular, whitened; pycnidia minute, black, situated just beneath the whitened epidermis which is easily detached and through which the minute ostiola protrude; spores oblong-ellipsoid, subtruncate at apices, 2 to 4 septate not constricted, brown, 10–12 × 4–6 μ, on short, hyaline, subcylindrical basidia.

On leaves of *Coccoloba uvifera*, Pueblo Viejo, Mexico, June, 1911, *Rev. H. Q. Morton*.

7. **Phyllosticta Mortoni** sp. nov.

Spots small, 1–3 mm. in diam., circular, at first black and surrounded by indefinite red or purple discoloration of the leaf surface, then becoming whitish in the center, and in age with the disappearance of the purplish spots running into brown, discolored areas; pycnidia black, sparse, covered then erumpent, amphigenous, about 100 μ in diam.; spores oblong-ellipsoid, continuous, hyaline, 4.5–7 × 2.5–3 μ.

On leaves of Mango, *Mangifera Indica*, Pueblo Viejo, Vera Cruz, Mexico, June, 1911, *Rev. H. Q. Morton 9*.

8. **Pyrenochaeta fraxinina** sp. nov.

Pycnidia 220–330 μ diam., immersed then erumpent, globose, centrally ostiolate, with the ostiola surrounded by continuous, acute-tipped setae which are 175–350 μ long; spores basillar or allantoid, straight or curved, hyaline, granular, or at times minutely nucleolate, 7–10 × 0.5–1 μ; sporophores hyaline, rather long.

On petioles of *Fraxinus*, Lyndonville, N. Y., October, 1910, *C. E. Fairman*.

[3] Fl. Crypt. Flandr. 1: 389, Sacc. Syll. 10: 318.

9. **Coniothyrium Chionanthi** sp. nov.

Pycnidia immersed, then erumpent, superficial among the fibers of the wood, minute, dull-black; spores numerous, oblong or ellipsoid, ends obtusely rounded, simple, continuous, hyaline at first, becoming smoky or brownish, 4–7 × 3–4 μ; basidia not seen.

On a decorticated branch of *Chionanthus virginica* L., Lyndonville, N. Y., May, 1911, *C. E. Fairman.*

10. **Diplodia Akebiae** sp. nov.

Pycnidia minute, black, buried then erumpent, elevating the bark in small pustules through which the ostiola protrude, scattered, simple; spores yellowish-hyaline at first, continuous, then brown, ellipsoid and uniseptate, slightly constricted at the septum, 13–20 × 10 μ.

On small branches of *Akebia quinata,* cult., Lyndonville, N. Y., July, 1911, *C. E. Fairman.*

Basidia not satisfactorily made out as the spores were embedded in a gelatinous substance. Asci not seen.

Valsaria Akebiae Ellis & Ellis has smaller spores and occurs in clusters.

11. **Cryptodiscus araneo-cinctus** sp. nov.

Apothecia scattered, gregarious or confluent, punctiform to 0.5 mm. in diam., sunk in the wood and opening by a minute round pore, then semi-erumpent with larger, round, or irregularly oblong mouths, surrounded by radiating or arachnoid filaments, sometimes becoming bare with age, brown or the same color as the wood externally, disc pale straw-colored surrounded by a yellow or brown irregular margin, rounded or oblong in form; asci cylindric, straight, 8-spored, 80 × 4–4.5 μ, surrounded by filiform nucleated paraphyses; sporidia uniseriate, oblong fusoid, straight or curved, granular or 2–4 nucleate, appearing faintly 1–3 septate, not constricted, hyaline to greenish-hyaline, 9–12 × 1.5–2 μ.

On a fallen decorticated limb in the woods, Lyndonville, N. Y. April, 1911, *C. E. Fairman.*

LYNDONVILLE, N. Y.

NEWS AND NOTES

Dr. W. A. Murrill sailed for Europe May 31, where he will spend several weeks studying in various European herbaria.

Mr. W. H. Long, forest pathologist in the United States Department of Agriculture, spent several days at the Garden in June, looking over certain collections of fungi causing heart rot of forest trees.

Professors L. H. Pennington and Guy West Wilson have been awarded scholarships at the Garden to assist them in their work on the fungi. Mr. Pennington will continue his work on *Marasmius* and Mr. Wilson on the Peronosporales.

Dr. Chas. H. Thom recently spent several days at the Garden consulting mycological literature.

The following new species of ascomycetes are described from North American material by Dr. H. Rehm:[1] *Nacvia canadica, Diatrype patella, Ombrophila limosa, Pezicula eximia and Mycosphaerella lageniformis.* The last named is from California and the remainder from Ontario, Canada.

Doctor W. C. Sturgis has recently published a second paper on The Myxomycetes of Colorado.[2] This paper contains the record of 39 species, of which 33 are reported for the first time from Colorado. Three of these are new to America and three are

[1] Colorado College Publications, science series 12: 435–454. 1913.
[2] Ann. Myc. 11: 154–155. 1913.

described as new species. The new species are: *Fuligo megaspora, Didymium anomalum* and *Enerthenema syncarpon.*

The total number of species reported in the two papers is 127. Previous to the publication of this work, few species had been recorded for the Rocky Mountain region. During a part of the time Doctor Sturgis was assisted by Professor Ellsworth Bethel who is an excellent collector and thoroughly familiar with the state.

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MYCOLOGIA

VOL. V SEPTEMBER, 1913 No. 5

ILLUSTRATIONS OF FUNGI—XV

WILLIAM A. MURRILL

The specimens used for the accompanying figures were all collected in the vicinity of New York City. None of the species represented are known to be dangerously poisonous, and at least one of them is recognized as an excellent edible mushroom.

Chanterel minor Peck

SMALL CHANTEREL

Plate 92. Figure 1. × 1

Pileus thin, fleshy, convex to expanded, irregular or depressed at times, gregarious, 1–2.5 cm. broad; surface glabrous, subrugose, ochraceous to orange; margin inrolled at first, entire or repand; context thin, pallid, mild, at length faintly peppery; lamellae decurrent, distant, very narrow, often forking, but seldom anastomosing, concolorous or somewhat paler; spores ovoid, somewhat one-sided, smooth, hyaline with a faint yellowish tinge, 8–9 × 4–5 μ; stipe slender, cylindric, equal, glabrous, shining, slightly striate at times, concolorous, usually solid, 2–5 cm. long, 2–4 mm. thick.

This tiny bright-colored species is known to occur on the ground in deciduous woods from Massachusetts to Alabama in the eastern United States and is reported from a few localities in the middle west.

Lepiota procera (Scop.) Quél.

PARASOL MUSHROOM

Plate 92. Figure 2. × 1

Pileus soft, fleshy, ovoid to expanded, umbonate, solitary or

[MYCOLOGIA for July, 1913 (5: 185–256), was issued July 10, 1913.]

gregarious, 8–16 cm. broad; surface radiate-fibrillose and rufescent beneath the cuticle, the cuticle thick, at first smooth and continuous, rufous to umber in color, at length torn asunder, except upon the umbo, into large irregular scales which become scattered and gradually fall away, margin deflexed, silky-fibrillose; context thick, soft, white; lamellae broad, close, white, at times yellowish or pinkish, tapering slightly behind, free, remote; spores ellipsoid or obovoid, apiculate, 1–2-guttulate, 12–18 × 8—12 μ; stipe tall, tapering upward from the bulbous base, hollow or fibrous-stuffed, the cuticle thin, flocculose, rufous or brownish, at length drawn apart into minute scales, 15–25 cm. long, 8–16 mm. thick, the base 2–3 cm. thick; annulus thick, soft, subcoriaceous, movable, apical.

This handsome edible species is found in thin soil in meadows, pastures, and open woods from New England to Alabama and west to Nebraska. It is also widely distributed in Europe and Asia, where it is highly esteemed as an article of food, in some places being dried in quantity for winter use. On account of its scaly cap and bulbous stem, it must be carefully distinguished from species of *Venenarius*.

Chanterel cinnabarinus Schw.

CINNABAR CHANTEREL

Plate 92. Figure 3. × 1

Pileus firm, thin, fleshy, convex to depressed or somewhat infundibuliform, often irregular in the larger specimens, gregarious or scattered, 1.5–3 cm. broad; surface smooth or slightly rugose, of soft compacted fibers, opaque, cinnabar-red, fading somewhat in the field and entirely in the herbarium; margin at first inflexed, undulate to lobed, concolorous; context whitish, tinged externally with red, thin, taste varying from mild to slightly acrid; lamellae long-decurrent, forked, interveined, distant, narrow, concolorous or slightly paler than the surface; spores ellipsoid, smooth, hyaline, 8–9 × 5 μ; stipe cylindric or tapering downward, terete, glabrous, smooth or slightly striate, concolorous, solid, 2–5 cm. long, 4–7 mm. thick.

This small species is conspicuous because of its brilliant coloring and occurs in abundance on the ground in deciduous or coniferous woods from New England to Alabama and west to Indiana and Ohio, as well as sparingly in certain parts of tropical America.

Entoloma Grayanum Peck

GRAY'S ENTOLOMA

Plate 92. Figure 4. × 1

Pileus convex to plane, gregarious, 5–8 cm. or more broad; surface smooth, glabrous, hygrophanous, dark-avellaneous to subumbrinous, margin entire, concolorous; context white, odor and taste farinaceous; lamellae adnate or slightly sinuate, subdistant, ventricose, white to rosy, the edges undulate; spores subglobose, angular, rose-colored, 7–9 μ; stipe equal or tapering downward, shining-white, longitudinally striate, glabrous, solid, white within, 6–10 cm. long and 1 cm. thick.

This species is quite common in woods in eastern North America during late summer and autumn. It is well to avoid species of *Entoloma* when gathering mushrooms for the table. Two European species, *E. lividum* and *E. sinuatum*, are recognized as poisonous.

Ceriomyces fumosipes (Peck) Murrill

SMOKY-STEMMED CERIOMYCES

Plate 92. Figure 5. × 1

Pileus convex, 4–7 cm. broad, about 1–1.5 cm. thick; surface tomentose, avellaneous with light-bay spots to umbrinous or dark olive-brown, very distinctly reticulate-rimose, the cracks becoming wider and whitish in color in older plants, while the areoles between contract almost into tufts, especially toward the margin; margin entire, fertile; context firm, fleshy, white, changing slowly and slightly to pale-blue, taste sweet; tubes plane in mass, somewhat depressed at maturity, equaling the thickness of the context, greenish-white to avellaneous; spores ellipsoid, smooth, deep ochraceous-brown, 14–16 × 7–8 μ; stipe somewhat ventricose, solid, white within, changing slightly to bluish beneath the cuticle, 3–4 cm. long, 0.7–1 cm. thick, finely scabrous or scurfy, avellaneous-umbrinous to fulvous, paler above, distinctly pale bluish-green at the apex.

This species occurs sparingly in woods, especially on roadside banks, from New York to the mountains of North Carolina and west to Kentucky. It may be readily recognized by the pale-bluish-green band at the apex of the stipe.

Ceriomyces communis (Bull.) Murrill

COMMON CERIOMYCES

Plate 92. Figure 6. × 1

The usual form of this very abundant and widely distributed species was figured and described in MYCOLOGIA for March, 1910. The form here represented is peculiar in having a bright-red, very finely tomentose cap which does not become rimose-areolate, and considerably smaller tubes than in the usual form.

Ceriomyces illudens (Peck) Murrill

DECEIVING CERIOMYCES

Plate 92. Figure 7. × 1

Pileus convex, 3–7 cm. broad; surface dry, finely tomentose, olivaceous, yellowish-brown or grayish-brown, sometimes slightly tinged with red, especially in the center; context whitish or yellowish, unchanging, rather spongy; tubes plane or convex in mass, adnate to adnexed, bright yellow to melleous without and within, mouths large, angular or subcircular, usually larger near the stipe; spores oblong or subfusiform, olive-green fading to yellowish-brown tinged with green, 11–13 × 4–5 μ; stipe nearly equal, usually tapering at the base, glabrous, whitish or yellowish to light-bay above, pale-yellow below, 3–7 cm. long, 5–10 mm. thick, coarsely reticulate entirely to the base in fully developed specimens, but only at the top in small plants.

This species occurs in woods and copses from Vermont to Alabama in the eastern United States. The stipe is coarsely reticulate, the tubes bright-yellow, and the cap usually olivaceous to yellowish-brown.

NEW YORK BOTANICAL GARDEN.

THE IDENTITY OF CANTHARELLUS BREVIPES AND CANTHARELLUS CLAVATUS

Edward T. Harper

(With Plates 93, 94 and 95)

The plants illustrated in plates 93 and 94, accompanying this article, are frequently met with at Neebish, Michigan. They grow on the ground in damp mossy places or among needles in coniferous woods. We referred them at first to *Cantharellus brevipes* Peck, but the illustration of *Craterellus clavatus* by Fries[1] suggested that Peck's species is the same as *Craterellus* or better *Cantharellus clavatus* of Europe, and further study of other illustrations and descriptions of that species appears to prove the identity beyond doubt. *Cantharellus clavatus* has been figured many times in European works on mycology. One of the latest illustrations is that in Rolland's Atlas Champignons (pl. 52). The plant is really a *Cantharellus* and has been so called by Corda, Bresadola and others. The description in Saccardo's[2] Sylloge fits our plant except that the hymenium becomes pale ochraceous pruinate rather than "whitish pruinate from the spores," which is necessarily the case since the spores are ochraceous. In dried specimens the spore pruina appears whitish over the dark background of the hymenium unless special attention is paid to the color. The pruinate surface is very noticeable. The spore measurements, $4–5 \times 10–12\,\mu$, agree with those of our plants exactly and also with those of *Cantharellus brevipes.*

Cantharellus clavatus has been reported from Maine by Sprague, according to Saccardo (l. c.) and Lloyd[3] has recognized it among plants sent to him from Montana, but he thought the spores of the Montana plant appeared hyaline under the microscope. The spores in our plants are pale-ochraceous.

[1] Fries, Sverige Svamp. *pl. 91.* 1836.
[2] Saccardo, Syll. Fung. 6: 519. 1888.
[3] Lloyd, letter 44, note 56.

Peck[4] described and illustrated *Cantharellas brevipes* in 1880. He has also recorded two other collections.[5] The fact that it is so rare in New York State and that it is really a *Cantharellus* accounts for its not being recognized as Persoon's species.

The illustrations in plates 93 and 94 show the appearance of the Neebish plants. The plants are usually quite regularly obconic or turbinate with the pileus truncate or slightly depressed and the acute margin even or slightly wavy as in plate 93. This is the form illustrated by Peck. The hymenium is a network of folds and wrinkles. The wrinkle-like lamellae are more nearly parallel toward the top and more reticulate below, the reverse of the condition in *Cantharellus floccosus*. Under favorable weather conditions the plant becomes broader and the margin is thin and lobed as in plate 94 *A*. Sometimes these luxuriant forms grow in dense clusters as in *B*. Sometimes the plants appear branched from a common stem. Sometimes they are irregular and the lobes on the pileus very long as in Britzelmayr's illustration (tab. 698). The flesh of our plants is whitish. The colors vary considerably. The pileus is yellowish or umber with tinges of purple or violet. It becomes faded, scaly and pitted when old. The hymenium is usually deep violet with flesh-colored tints. A whole series of variously colored forms have been noted in Europe.

It has been recognized already that the plants referred to as *Craterellus clavatus*, by Peck,[6] are *Craterellus pistillaris* Fries. Peck speaks of their close resemblance to *Clavaria pistillaris* and describes the margin of the pileus as obtuse and crenate. *Craterellus pistillaris* has been taken in this country for a form of *Clavaria pistillaris* by Atkinson[7] and Lloyd (l. c.). Fries said *Craterellus pistillaris* was frequently found in pine woods about Upsala where true *Clavaria pistillaris* was never found. It is interesting that our plants illustrated in plate 95 are found in coniferous woods at Neebish, Michigan, and we have never seen *Clavaria pistillaris* there. Only once has the plant been collected at Neebish, and then not in coniferous woods. It is

[4] Peck, Ann. Rep. N. Y. State Mus. **33**: *21. pl. 1, f. 18–20.* 1880.

[5] Peck, Ann. Rep. N. Y. State Mus. **51**: *298.* 1897.

[6] Peck, Ann. Rep. N. Y. State Mus. **32**: 35, 1880, and Bull. N. Y. State Mus. **2**: 48. 1887.

[7] Atkinson, Mushrooms, *203.* 1903.

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CRATERELLUS PISTILLARIS. FR.

very common in frondose woods elsewhere in Michigan and Wisconsin. Other collectors may not have this experience however.

Atkinson and others are undoubtedly right in considering Fries' plant a variety of *Clavaria pistillaris* and it should be placed in a group with that species. Fries recognized the similarity of the two but probably placed the plant in the genus *Craterellus* because of the depressed pileus. The hymenium is usually continuous to the apex. Schaeffer's figures (290), are supposed to represent this form but they appear to us more like small forms of *Cantharellus clavatus.*

Plate 95 shows the common forms of the plant as found at Neebish: (*A*) a form with the hymenium nearly smooth and the margin obtuse and even; (*E*) a form with a wrinkled hymenium and margin of the pileus crenate; (*B*) a very small plant; (*C*) the extreme form in old plants with the hymenium very rugose and pitted; (*D*) a wrinkled pileus with slight umbo in the center. The plants are spongy and soon become hollow. The base of the stem is often bulbous. The colors are reddish-brown like *Clavaria pistillaris,* but the hymenium is often dull violet with yellowish tints above and on the pileus. The spores are $6–7 \times 10–12\,\mu$; basids club-shaped, $12 \times 60\,\mu$; sterigmata $10\,\mu$ long. The spores of *Clavaria pistillaris* are in our specimens ovate, $4–5 \times 8–11\,\mu$. The flesh of our plants is not nearly as solid as that of *Clavaria pistillaris.* The two forms, however, run together. Hard's[8] illustration of *Clavaria pistillaris* (fig. 396), appears like an intermediate form, and *Craterellus corrugis* Peck,[9] must be something similar. Forms of *Clavaria pistillaris* with the apex pinched in are well known.

A letter from Mr. C. G. Lloyd confirms both of the above identifications. Mr. Lloyd has examined Persoon's type of *Merulius clavatus* at Leiden and a co-type specimen of Fries' *Craterellus clavatus* at Kew. He has also seen a type specimen of Fries' *Craterellus pistillaris* at Kew and Peck's specimens at Albany.

[8] Hard, Mushrooms. *f. 396.* 1908.

[9] Peck, Bull. Torrey Club 26: 69. 1899.

THE STRUCTURE OF SIMBLUM SPHAEROCEPHALUM

HENRY S. CONARD

(WITH PLATES 96 AND 97)

In October, 1911, Miss Winnie Gilbert, a student at Grinnell College, Iowa, brought in a specimen of the pink stink-horn, *Simblum sphaerocephalum* Schlecht. It was found on the north side of a deep railroad cut one mile west of Grinnell. Further search in this place resulted in the collection of several mature specimens and a number of "eggs." They grew about half way up the slope, facing south, on Marshall silt loam that had slid down the bank many years ago, and at about the level of the boundary between the loess and the glacial drift. Perhaps there are special moisture conditions at this level, though other vegetation does not suggest this. With them was *Poa pratensis* as dominant plant, as well as seedlings of *Acer negundo, Physalis* spp., *Aster* spp., etc. Two or three weeks later my colleague, Professor H. W. Norris, found specimens on a hillside above Skunk River, three miles southwest of Turner Station (southeast corner of section 5, Richland Township, Jasper County, Iowa). Some of the smaller "eggs" were cut open and killed in chromacetic fluid and later sectioned on the serial microtome. The rest of the material was preserved in alcohol. The following studies were made of the preserved material. My best alcoholic specimens have since been deposited with Professor Macbride at the State University of Iowa, Iowa City. A brief account of this find was presented to the Iowa Academy of Science in April, 1912.[1]

Simblum sphaerocephalum was originally described by Schlechtendal (1861) from Argentina, where it is common. Similar plants have been collected in southern Brazil and in Venezuela, and described under different names. In North America it is known from Astoria and Cold Spring Harbor, Long Island;

[1] Proc. Iowa Acad. Sci., 19: 103. 1912.

Nebraska; Kansas; Washington, D. C.; Talbot County, Md.; and Texas (Lloyd, 1909, p. 67; Long, 1907). We follow Fischer (1890, p. 59) in reducing to synonymy the names *S. rubescens, S. australe, S. Lorentzii,* and *S. pilidiatum.* In view of the rarity of this plant in the United States, we offer the following detailed observations.

The white volva, flesh-pink stalk and receptaculum, and umber-brown spore-mass make this fungus a curious and striking object (fig. 5). Its odor is somewhat nauseous, but not strong. The size of our plants is shown by the following tables of measurements:

MEASUREMENT OF MATURE PLANTS, IN CM.

Total Height	Length of Stalk	Length of Head	Diameter of		
			Head	Stalk	Volva
5[2]	3	1	1.75	1.2	2.3
7	6.3	0.7	1.8	1.3	
5.5		0.7	1.3	1.0	
8.5	6.5	1.5	2.5	2.1	3
10 (?)	8.0	1.5	2 (?)	1.8	3
7	5.8 (?)	1.0	1.5	1.3	
5.5	4.3 (?)			1 (?)	
					2.5[3]

MEASUREMENTS OF "EGGS," IN CM.

Height.	Diameter.	Rhizomorph.
2.2	1.5	
2.6	1.7	1.9
2.9		
2.3	2.15	3.0
1.9	1.6	
	1.5	

When lifted carefully each plant was found to have a stout white rhizomorph running into the ground (figs. 1, 5). These strands are smooth, solid, and gently tapering. The longest we have is 3 cm. with a diameter of 2 mm. The egg-stage is obconical in shape (fig. 1), white, rather firm to the touch, but not turgid. When cut in half lengthwise the "egg" shows first a tough, white peridium (fig. 1), then a thick layer of firm, translucent, gelatinous matter traversed by strands or trabeculae of denser white tissue. On comparing cross-sections (fig. 2) it is seen that these

[2] Including rhizomorph.

[3] Has also a rhizomorph 2 cm. long.

strands are really anastomosing partitions, connecting with the peridium externally and with the bars of the receptaculum within. The gelatinous layer is therefore divided up into many irregular longitudinal chambers. A similar arrangement of partitions in the volva jelly is described by Fischer (1901) in *Simblum periphragmoides,* and by Long (1907) in this species.

So far as is shown by the rather advanced stages at our disposal, *Simblum sphaerocephalum* agrees precisely in structure with other Clathraceae as described by Fischer (1890–1910). The stalk of the receptaculum is traversed by a central strand, (*S*) of gelatinous hyphae, which is continuous with the gelatinous filling of the chambers of the stalk (figs. 1, 3). The pseudoparenchymatous tissue is composed of small spherical cells, arranged in a network of anastomosing plates which form the walls of the chambers (figs. 3, 7, 8). These walls are much folded in the egg stages. Though the chambers seem to be all connected with one another and with the central cavity of the stalk, they do not connect definitely with the tissues surrounding the stalk. Elongation of the stalk is manifestly due to a great increase in size of the pseudoparenchyma cells, as shown by figures 7 and 8. Though these are not taken from the same plant, their evidence seems conclusive. Coupled with this enlargement is a general expansion of the stalk in all directions, a straightening of the folds of the chamber walls, and liquefying of everything except the pseudoparenchyma.

In the head region, the bars of the receptaculum (*Rp*) are found on the surface of the gleba, in full view when the volva-jelly is removed. From each bar a plate of permanent hyphal tissue (*Pl*) extends to the peridium. Since the receptaculum is net-like, these plates enclose prismatic spaces (*G*) which correspond in position and number to the meshes of the network. It is in these spaces that the volva-jelly is contained. In our specimens (and also in *S. periphragmoides,* according to Fischer, 1901) these spaces bend downward parallel to the stalk, and end near the base of the "egg." Doubtless they originate when the "egg" is very young, and before the stalk is formed (Cf. text fig. 1, *G*). As growth proceeds, the volva extends by enlargement of its upper parts (above ϕ, text fig. 1), and the stalk is

intercalated beneath the head. Meanwhile the plates elongate *pari passu,* resulting in the condition shown in text fig. 3. If this be true, as seems almost certain, the stalk would seem to be an organ of much more recent origin than the head of the receptaculum. It may be regarded as an extreme development of the basal ring of the receptaculum of *Clathrus* (text figs. 1, 2, α). This agrees with the generally accepted view that *Clathrus* is one of the most primitive of the Clathraceae.

Fischer (1890, p. 11) supposes that the difference between the early stages of development of *Simblum* and *Clathrus* would be that in the former the branches of the central strand come off

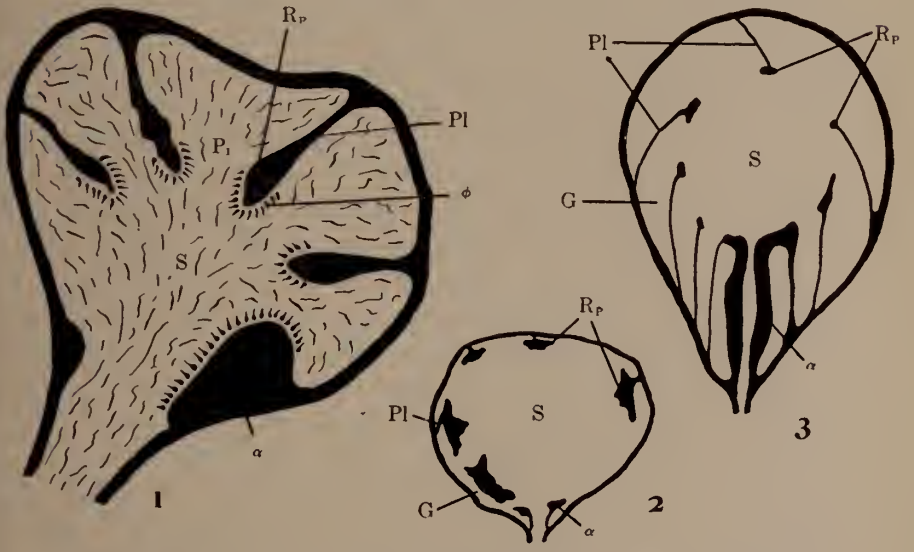

FIG. I.—1. Vertical section of very young egg of *Clathrus cancellatus,* from Fischer 1890, pl. 1, f. 3.—2. The same, mature egg; l. c. f. 6.—3. Diagram of vertical section of mature egg of *Simblum sphaerocephalum, a* lowest ring of receptaculum; other letters as in plate.

higher up than in the latter ("Der Unterschied der ersten Fruchtkörperanlage von *Simblum* gegenüber derjenigen von *Clathrus* besteht also darin, dass vom Centralstrang hier erst weiter oben als dort Zweige abgehen"). But if the central strand branches higher up, there should be no volva-jelly around the stalk—unless the branches force themselves down between the layers of the peridium and the plates, parallel to the stalk. It seems much

more reasonable to say that the branching of the central strand takes place when as yet there is no stalk, exactly as in *Clathrus* (text fig. 1). The branches are then fixed to the peridium, as it were, at their outer ends. When their inner ends are raised up by the intercalation of a stalk, the outer parts of the branches are drawn out into vertical columns, parallel with the stalk. Thus the stalk of *Simblum,* originating as a sterilized basal portion of the receptaculum, becomes an independent organ, bearing the fertile receptaculum at its upper end. The usefulness of such a stalk for the better distribution of the spores, as Moeller (1895) suggests, cannot be doubted.

From a study of Burt's (1894) description of *Anthurus borealis* and Fischer's (1910) of *Aseroe,* it appears that in these forms also the stalk develops in the manner outlined above, rather than by a branching of the rudiment of the central strand higher up, and a forcing of the tips of the branches downward between the layers of the peridium. Indeed this view was mentioned as probable by Burt (1894, p. 495). It is indicated also by Moeller's description of the development of *Colus Garciae* (1895, p. 39). A study of the plates in the volva-jelly of *Colus hirudinosus, Kalchbrennera,* and *Laternea* would be helpful in this connection. Tulasne's (1846) figure of the egg of *Colus hirudinosus* shows the plates from the fertile parts of the receptaculum to the volva, but shows no plates in the region of the stalk. His figure 16 is a transverse section of the fertile portion and figure 15 an outside view of the entire egg. The matter is therefore not settled for this species.

In *Lysurus, Anthurus* and *Aseroe* it is possible to consider the stalk as a fusion of the lower vertical bars of a clathrate receptaculum. *Clathrella chrysomycelina* and *Laternea* apparently lead to such a view. In *Simblum* there is no indication whatever of such an origin. Now, in all stalked Clathraceae, the stalk is surrounded by a sheath of gelatinizing hyphae, to which the plates attach, as in *Simblum.* But in the fertile portion the plates attach directly to a line or furrow along the arms or branches of the receptaculum. It seems reasonable therefore to believe that the stalks are homologous structures throughout the family, and of the same nature as described for *Simblum.* The sheath of the

stalk is then the place of attachment of the plate tissue to the lowest horizontal bars of the receptaculum, which has become extended into a sheath as the bars elongated to form the stalk.

The superficial position of the bars of the receptaculum in the head of *Simblum sphaerocephalum* has already been remarked (fig. 1). In this it differs markedly from *S. periphragmoides* (Fischer, 1893, 1900, 1901) whose bars are deeply embedded in the gleba. On critically examining the relation of gleba to receptaculum, we find in many cases gleba-chambers bounded on one side by fertile hymenium and on the other by pseudoparenchyma of the receptaculum-arm (figs. 9, 12). The transition from hymenium to pseudoparenchyma, however, is not gradual, but abrupt. Sometimes a narrow strip of tramal tissue lies between them. In many cases it is evident, so far as sections can prove, that the tramal hyphae are continuous with the pseudoparenchyma (fig. 10). Thus the pseudoparenchyma has a double origin. Indeed one frequently finds cavities separating the portions of different origins (fig. 10). These facts support Fischer's view, proposed in 1890, and proven for *Dictyophora irpicina* in 1910 (*b*), that the pseudoparenchyma represents sterile hymenial tissue, or a hymenium of paraphyses without basidia. In this case the cavities in the pseudoparenchyma of *Simblum* may be considered to be rudimentary gleba-chambers (fig. 10, *f*). Burt (1894) maintained that the pseudoparenchyma of *Anthurus borealis* is of strictly "cortical" nature, and has no connection with the surrounding gelatinizing hyphae. This idea was apparently drawn chiefly from sections in the stalk region, where the tissues are much more sharply separated. After the first rudiments of the stalk are formed as the lowest mesh of a net-like receptaculum, according to our theory, the further development of the stalk tissues may be quite independent of one another. Thus Burt's observations would be entirely right, and in no contradiction with Fischer's (1900) and my own. In one of my plants of *Simblum* two bars of receptaculum tissue were found near the center of the head, completely embedded in the gleba (fig. 6). Following these upward, they joined one of the upper bars of the receptaculum. Another specimen showed bars of the receptaculum extending deep into the gleba. These irregularities might

easily occur if hymenium and pseudoparenchyma are homologous tissues. Certain patches in the midst of the branches of the central strand in some of my sections give an appearance, in texture and staining, of a tissue intermediate between hymenium and pseudoparenchyma. Unfortunately gelatinization is so far advanced that no details are available. The center of each patch is occupied by numerous globular bodies of about the size and color of spores.

Fischer's (1890, p. 7) suggestion that the hymenium is fertile wherever it lines a cavity and sterile when two layers are appressed without a space between, is untenable. Not only is pseudoparenchyma developed adjacent to gleba-chambers (fig. 9), but basidia are borne in such narrow chambers that the space is literally obliterated (fig. 12). Moeller (1895, p. 31) has already emphasized these objections to Fischer's view. The stimuli which guide the development of an embryonic tissue must be much more profound than this.

The gleba of *Simblum sphaerocephalum* is traversed by stouter strands of tissue similar to that of the trama, constituting the "branches of the central strand (*P*)" of Fischer. Each such branch (figs. 1, 11) runs radially outward from the central gelatinous tissue of stalk and head, to merge into the volva-jelly at the middle of one of the meshes of the receptaculum. Each mesh is traversed by one such branch. Some branches are rod-like and reach the surface of the gleba in a circumscribed spot. Others are ribbon-like, and form a line on the surface of the gleba. Tangential sections of the surface of the gleba show the gleba-chambers as narrow branching slits radiating from the branch of the central strand and nearly at right angles to the bars of the receptaculum. This indicates an origin such as Fischer has described in other Clathraceae. The chambers probably result from the growth of trama-plates from the branch of the central strand toward the bars of the receptaculum. But no order was found elsewhere in the arrangement of the trama-plates or gleba-chambers.

In all of our material the dense mass of spores hides the basidia. Probably these had already begun to gelatinize. We found one basidium, apparently in normal condition. It was

nearly globular (fig. 4), with a short constricted base, and two short sterigmata at the apex. The basidium is about 2.5 μ in diameter and 4.5 μ tall, with sterigmata about 0.5 μ tall. The spores are ellipsoidal, with a single large nucleus, and measure 3 μ by 1.5 μ. These dimensions, so characteristic of Phalloids, are of the same order of magnitude as those of bacteria—a fact which coincides with the idea that both of these groups of plants are distributed by flies.

SUMMARY

1. *Simblum sphaerocephalum* Schlecht., a common fungus in parts of South America, is now known from New York, Maryland, District of Columbia, Iowa, Nebraska, Kansas, and Texas. It shows every essential character of the Clathraceae.

2. The stalk elongates by enlargement of the cells of the pseudoparenchyma.

3. The bars of the fertile receptaculum are superficial on the gleba.

4. The plates which divide the volva-jelly are vertical in the region of the stalk, enclosing a mass of jelly for every mesh of the receptaculum. Their position is believed to be due to the late development of the stalk in a rudiment which would be identical in early structure with that of a *Clathrus*. The stalk of *Simblum* is therefore a highly developed basal ring of a clathrate receptaculum, and not a fusion of vertical columns.

5. Pseudoparenchyma of the receptaculum may be regarded as sterile hymenium.

6. In the superficial portions of the gleba, at least, the chambers originate by growth of trama-plates from the branches of the central strand toward the receptaculum-arms.

For use of the literature which has made this paper possible, I am indebted to the generous loan-system of the Missouri Botanical Garden. To the officers of the Garden I wish to extend hearty thanks. The photomicrographs are by Mr. Paul M. Smith.

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EXPLANATION OF PLATES

Key to index letters, the signs being mostly those used by Fischer. The figures are all of *Simblum sphaerocephalum*.

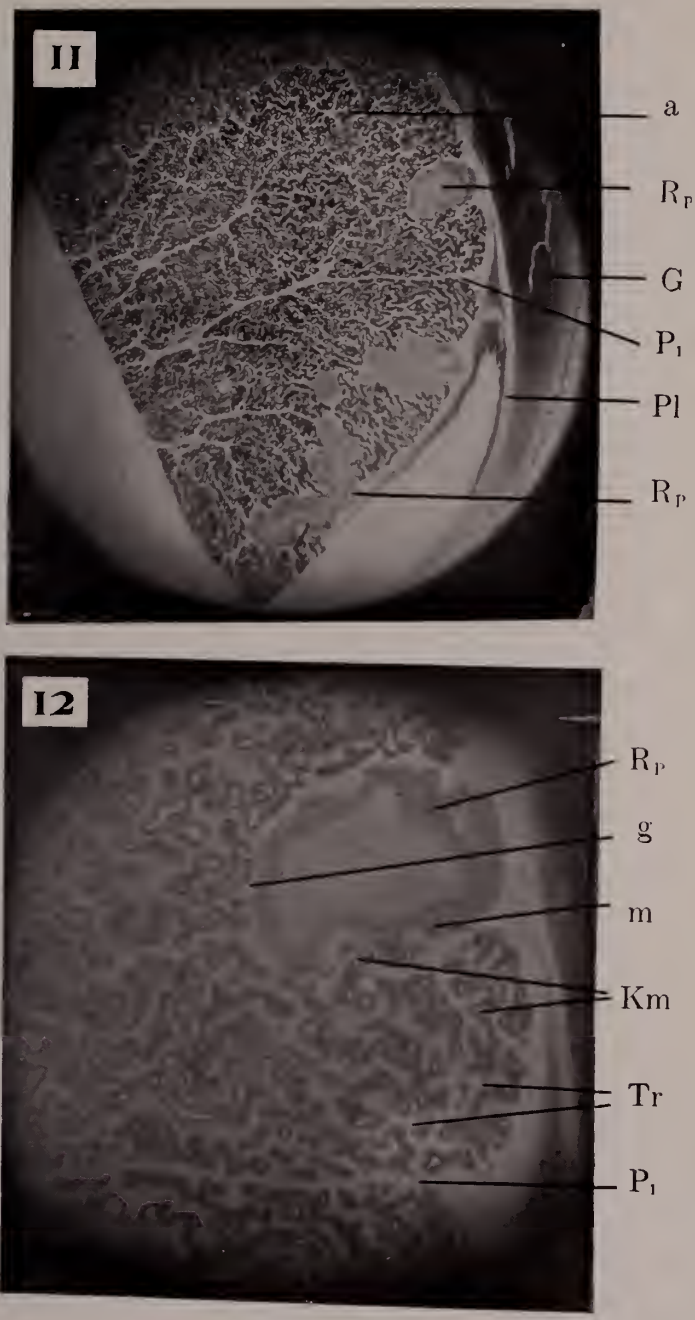
a, gleba.

f, rudimentary gleba-chambers in pseudoparenchyma of receptaculum.

G, gelatinous part of volva.

g, gleba-chamber bounded partly by basidial layer and partly by pseudoparenchyma of receptaculum.

SIMBLUM SPHAEROCEPHALUM SCHLECT.



SIMBLUM SPHAEROCEPHALUM SCHLECT.

Km, gleba-chamber.
Pl, plate-like partition in volva-jelly.
P_1, branches of central strand.
R, cavity of arm of receptaculum (gelatinous).
Rp, receptaculum.
S, central strand of gelatinizing hyphae.
Tr, trama-plates.
x, peridium.
y, rhizomorph.
a, lowest ring of receptaculum.
ϕ, basidial layer (hymenium).

PLATE XCVI

1. Longitudinal section of nearly mature egg, measuring 2.35 cm. × 2.15 cm. Camera sketch.

2. Transverse section of egg through stalk, showing the partitions in the volva-jelly. Camera sketch.

3. Folded pseudoparenchyma tissues in longitudinal section of stalk in egg stage. The cavity of the stalk is on the right, *S*, and the volva-jelly (*G*) on the left. Camera sketch.

4. Basidium, from a microtome section. Camera drawing.

5. Mature *Simblum* 5 cm. tall. Camera sketch of alcoholic specimen.

6. Transverse section of halved egg, through middle of head. Camera sketch.

7. Cells of pseudoparenchyma of stalk from egg stage; camera drawing.

8. Cells of pseudoparenchyma of stalk teased out from a fully elongated specimen; camera drawing with same magnification as fig. 7.

9. Section of receptaculum arm and gleba; semi-diagrammatic camera sketch. From (*g*) in fig. 12.

10. Transverse section of pseudoparenchyma of arm of receptaculum, showing rudimentary gleba-chamber (*f*). Tramal tissue below (*Tr*) and cavity of arm (*R*) above. Camera drawing.

PLATE XCVII. PHOTOMICROGRAPHS

11. Transverse section of head of egg stage.

12. Portion of the same section, more highly magnified.

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GRINNELL, IOWA.

A METHOD OF DETERMINING IN ANALYTIC WORK WHETHER COLONIES OF THE CHESTNUT BLIGHT FUNGUS ORIGINATE FROM PYCNOSPORES OR ASCOSPORES[1]

F. D. Heald

(With Plates 98–101)

Introduction

In studying the dissemination of the chestnut-tree blight fungus [*Endothia parasitica* (Murr.) And. and And.] it is sometimes of importance to be able to determine whether the colonies of *Endothia* appearing in poured plates originate from pycnospores or ascospores. This is especially true in case of the analysis of soil for the presence of the fungus, the quantitative determination of viable spores retained in spore traps, and other similar operations.

During the past winter thousands of cultures of the blight fungus have been made, especially in studying the problem of dissemination, but before beginning the work the method here outlined was worked out, as it appeared to the writer of fundamental importance.

At first thought the possibility of differentiating ascospore and pycnospore colonies seemed somewhat remote, but the striking difference in size of pycnospores and ascospores offered the first clue to the problem. The approximate dimension of the spores (ascospores $5 \times 10\,\mu$; pycnospores $1 \times 3\text{–}5\,\mu$) gives rather an imperfect notion of their difference in magnitude, but calculation will show that the ascospore of average size has a volume about fifty times that of the average pycnospore. It seemed evident then that the greater size of the ascospore would result in a more rapid growth of the colonies originating from them.

[1] Work in coöperation with the Pennsylvania Chestnut-Tree Blight Commission, Philadelphia, Pa.

The medium found most suitable for this work was 3 per cent. dextrose agar, plus 10, made according to the standard bacteriological formula. The comparative rate of growth from ascospores and pycnospores was first tested in this medium by means of hanging-block cultures. The pycnospores used were obtained from spore-horns grown in damp chambers in the laboratory. The ascospores were obtained by placing flamed object slides over moistened bark bearing perithecial pustules and collecting the expelled spores. In making the pycnospore cultures a drop of sterile bouillon was placed on a flamed slide and a small spore-horn added to it. One or more dilutions were made from this to other drops of sterile bouillon and a short streak was made from the final dilution upon the surface of the cover glass, after which the streak was covered with melted agar cooled to 42° C. In making the ascospore cultures a drop of sterile bouillon was placed over a spore print on a slide. Dilutions were made from this to a second slide, and the planting made directly from the spore dilution.

By these methods there was never any trouble in securing pure cultures in the hanging drop cells.

GERMINATION OF PYCNOSPORES AND ASCOSPORES

During the first part of the germination period the pycnospore increases in size until it is oval or oblong in form and slightly in excess of the diameter of the germ tube that is to be produced (plate 98, figs. 1–3). A hypha begins to grow out from one end of the spore and this is generally followed later by one from the opposite end so that at temperatures from 22° to 25° C., only an unbranched linear aggregate has been produced at the end of 24 hours. During the next 24 hours, however, branching generally begins, the first branch originating a little beyond the limits of the spore, thus producing a distinct Y-type of growth (plate 98, figs. 4–6).

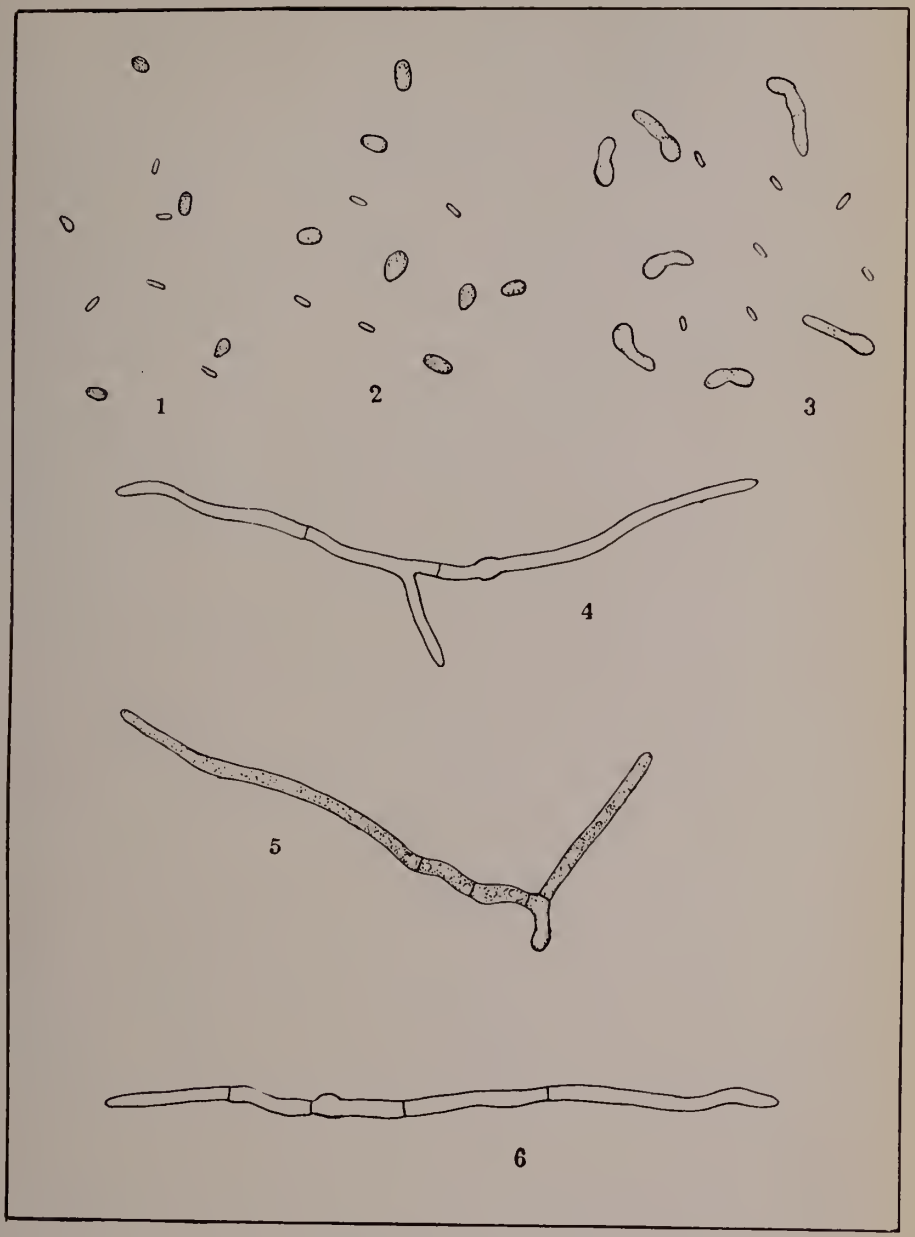
Each cell of an ascospore generally gives rise directly to at least one vigorous hypha, but occasionally one cell fails to germinate. In many spores each cell gives rise to a lateral hypha a little later. In case a lateral hypha is not formed directly from

the spore cell, one originates a few mikrons beyond the spore wall, giving in the majority of cases a growth with pronounced decussating branches (plate 99, figs. 1–5).

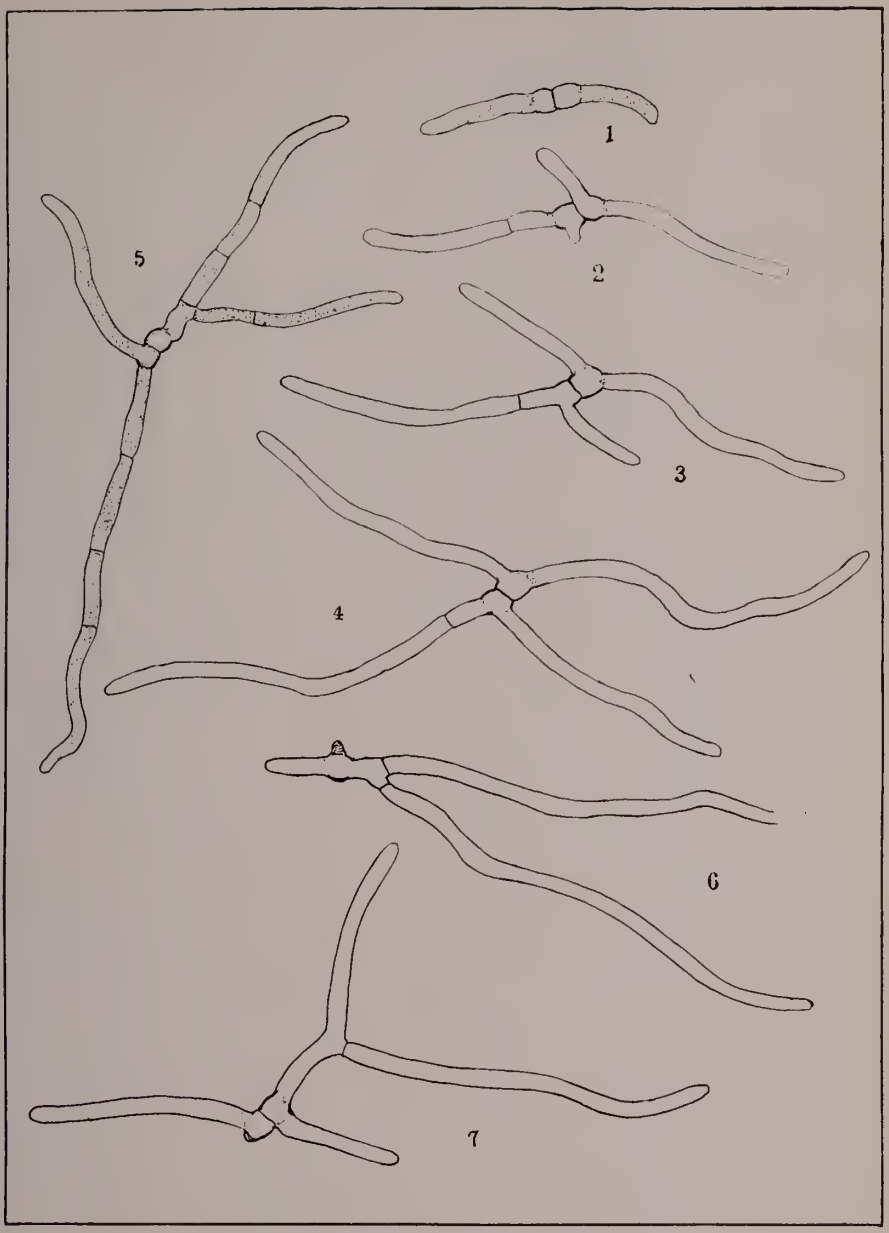
Tests of the comparative rate of growth of pycnospores and ascospores were first made at 22° C., but it was found by later work that 25° C. gave a more pronounced difference. Camera lucida drawings were made at hourly intervals for the ascospores after the first eight hours and at intervals of two hours for the pycnospores. At the end of eight hours the ascospores produced a strong hypha from each cell, while the pycnospore had not yet swollen to its full size; after 22 hours the pycnospore had produced a short unbranched hypha with little or no septation, while the ascospore had produced a much branched linear aggregate of cells (plate 100). The series of drawings shown will serve to emphasize the pronounced difference in the growth from the pycnospores and ascospores.

PLATE CULTURES

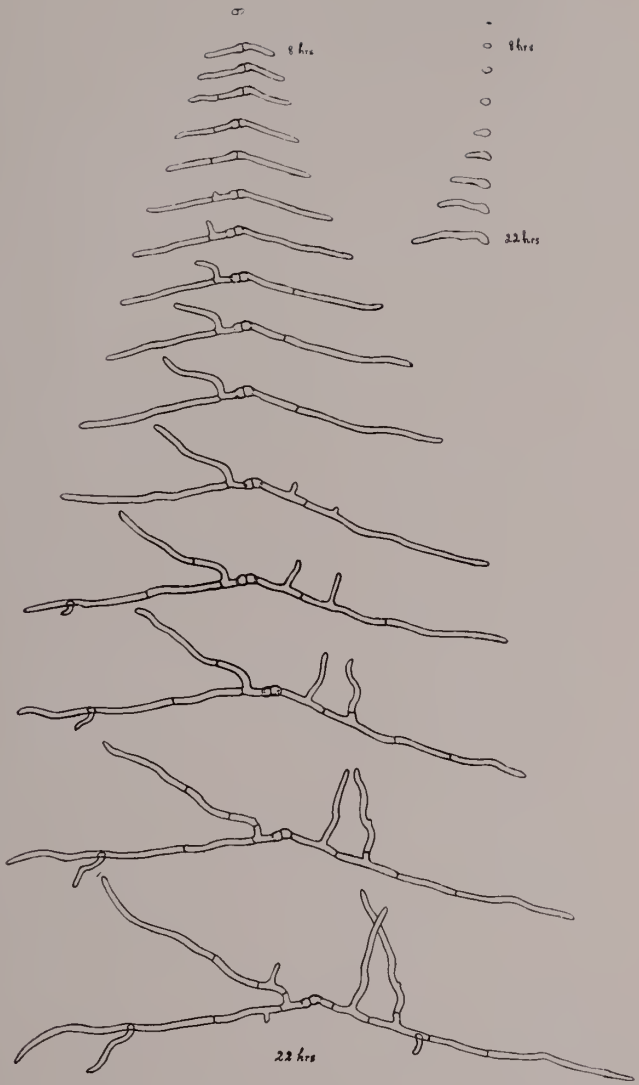
The marked difference in the rate of growth from pycnospores and ascospores suggested the strong probability of being able to differentiate the two types of colonies in plate cultures by the size of the colonies at the end of a certain time. Various culture media were tried but 3 per cent. dextrose agar, plus 10, again appeared to be the most suitable. The poured plates were made in the usual manner from spores obtained in the same way as for the hanging-block cultures, and practically pure cultures of the blight fungus were always obtained. The cultures were held at a constant temperature of 25° C. All of the tests made showed that ascospore colonies became visible and conspicuous when the pycnospore colonies were still minute and invisible to the naked eye. At the end of three days' time, colonies originating from ascospores were 0.5–3 mm. in diameter, the size depending upon the crowding in the plate, while those originating from pycnospores were not visible to the naked eye (plate 101); after four days of growth the ascospore colonies were 1–4 mm. in diameter while the pycnospore colonies showed an average diameter of 400 μ. The time of appearance of the yellow centers in the colo-



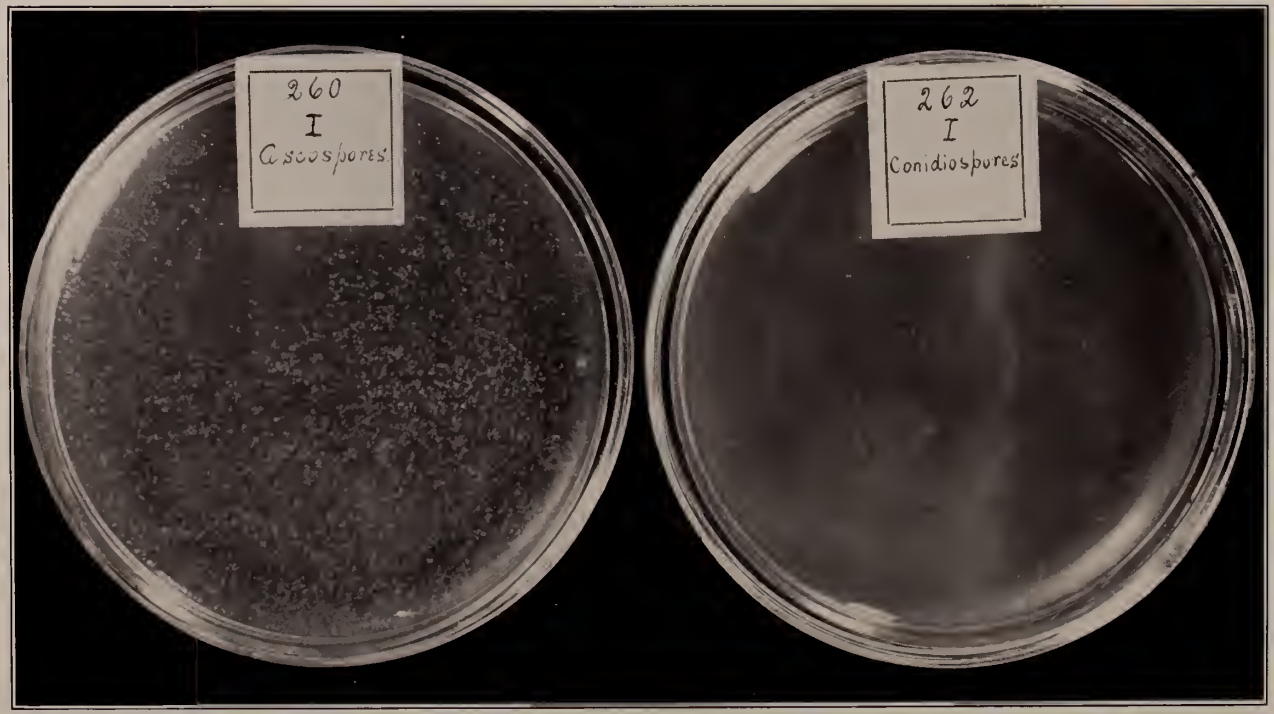
GERMINATION OF PYCNOSPORES



GERMINATION OF ASCOSPORES



SERIES SHOWING COMPARATIVE GROWTH IN HANGING DROP CULTURES



COMPARATIVE GROWTH FROM ASCOSPORES AND PYCNOSPORES

nies does not appear to be of importance since this varies according to crowding, depth of medium and origin. The reliability of this method for differentiating pycnospore and ascospore colonies has been substantiated by numerous cultures, but the importance of holding the cultures at a constant temperature must not be overlooked.

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EXPLANATION OF PLATES

PLATE XCVIII

Germination of pycnospores in 3 per cent. dextrose agar, plus 10, at 22° C: 1, after 12 hours; 2, after 16 hours; 3, after 22 hours; 4, 5, 6, after 36 hours. These illustrate the linear and the Y-types of germination.

PLATE XCIX

Germination of ascospores in 3 per cent. dextrose agar, plus 10, at 22° C. 1–4, a series showing stages in the growth from a single spore: 1, at 11:45 A.M.; 2, at 2:45 P.M.; 3, at 4:45 P.M.; 4, at 7:45 P.M.; 5, 6, 7, after 24 hours. In 4 each cell has produced two hyphae; in 5 one cell has produced two hyphae, while a strong lateral has grown out from the main axis just beyond the other cell of the spore; in 6 one cell has produced a short lateral but no terminal hypha; in 7 one cell of the ascospore failed to produce a germ tube.

PLATE C

A series of drawings showing the comparative growth from an ascospore and a pycnospore in 3 per cent. dextrose agar, plus 10, at a temperature of 25° C. After eight hours drawings were made at hourly intervals for the ascospore series and every two hours for the pycnospore series.

PLATE CI

Poured plate cultures of ascospores and pycnospores to show comparative growth in 3 per cent. dextrose agar, plus 10, at a temperature of 25° C. Photograph taken after three days of growth. Pycnospore colonies not yet visible to the naked eye.

NEWS AND NOTES

Dr. Frank D. Kern has been appointed professor of botany in the Pennsylvania State College.

Professor E. J. Durand of Missouri State University was a recent visitor at the New York Botanical Garden.

Professor Mel. T. Cook delivered a lecture in the museum building of the New York Botanical Garden on June 14. The subject of the lecture was "Diseases of Fruit Trees."

Mr. Guy West Wilson, graduate student in Columbia University during the past year, has been appointed special agent by the United States Bureau of Plant Industry for the investigation of the chestnut blight fungus and its relation to tannin and other plant products. He is associated in this work with Professor Mel. T. Cook at Rutgers College, New Brunswick, New Jersey.

The New York Botanical Garden received in July a collection of 213 specimens of fungi and slime moulds from Porto Rico, collected by J. R. Johnston.

The *Botanical Gazette* for June contains an article by Howard S. Reed and J. S. Cooley on the transpiration of apple leaves infested with *Gymnosporangium*. A retardation of transpiration in the diseased leaves has been shown. Since it is known that transpiration and growth are intimately associated it is believed that the decrease in transpiration in the diseased leaves may be one of the factors in determining the bad physiological condition of such trees.

Bulletin No. 281 of the Bureau of Plant Industry of the United States Department of Agriculture contains a discussion by L. L. Harter and Ethel C. Field on a dry rot of sweet potatoes caused by a fungus which has been named by them *Diaporthe Batatatis*. The fungus is thought to represent the perfect stage of *Phoma Batatae* Ellis and Halsted. The fungus is not a vigorous parasite and the disease is principally a storage trouble and is characterized by a drying and shriveling of the potatoes with the pycnidia forming on the surface. In the greenhouse the pycnidia also occur on the leaves and stems as well as the roots of the infected plants.

It is suggested, in order to prevent the spread of the trouble, that diseased potatoes should be cooked before being fed to stock. Diseased potatoes should not be used for fertilizer. Sterilization of seed bed is also suggested. No experiments were conducted in controlling the disease.

In farmers' bulletin No. 544, W. A. Orton summarizes the principal potato-tuber diseases and discusses the best means of eliminating or controlling them and thereby materially increasing the potato yield. It is claimed that the potato yield is only about one half what it might reasonably be expected to be per acre.

In *Science* for July 11 an article appears by Professor H. L. Bolley, of the North Dakota Agricultural College, on the complexity of the microörganic population of the soil. The article is in part an answer to one by E. J. Russell of Rothamsted Experiment Station which appeared in *Science* for April 4.

Professor Bolley agrees with Russell in many of his statements but takes exception to assuming that protozoa are the principal crop-limiting factor in deteriorated soils. Bolley claims that if we have purified seedlings placed in a purified soil they show no tendency to deteriorate. He also claims that species of fungi such as *Fusarium, Alternaria, Helminthosporium,* etc., in the soil are the real crop-limiting factors, aside from mineral elements and atmosphere, and that crop deterioration is probably a problem of crop sanitation as involved in infectious diseases. According to this theory sterilization is beneficial in that it destroys harmful fungi, the chief crop-limiting factors.

Circular No. 131 of the Bureau of Plant Industry contains a paper by Dr. C. L. Shear and Neil E. Stevens on the culture characters of the chestnut blight fungus and its near relatives. *Endothia parasitica* (Murrill) Anderson & Anderson has as its near relatives, *Endothis gyrosa, Endothis radicalis* and a variety of the latter species.

More than two thousand cultures of these fungi were made in order to study the behavior of the various species on different kinds of culture media. The results of these studies indicate that the different species have constant and easily recognized culture characters. *Endothia parasitica* can be distinguished by the peculiar orange-colored surface growth produced at the bottom of the potato agar slants. The early appearance of the orange color of the mycelium is also characteristic and ordinarily sufficient for identification.

On corn meal, *Endothis parasitica* is characterized by numerous small pycnidia and the absence of color changes in the medium. As compared with *Endothis parasitica, Endothis radicalis* is characterized by fewer and larger pycnidia which also appear at a later stage and by the perilla purple reaction of the medium; *Endothia radicalis mississippiensis* by the larger pycnidia and the orange chrome color of the mycelium appearing at the end of the week; and *Endothia gyrosa* by its tardy *spore production* and the formation of elevated or subcolumnar pycnidial stromata.

In order to make our herbarium records more complete, the New York Botanical Garden desires fresh specimens of any of the fleshy cup-fungi (Discomycetes) either large or small which are suitable for colored drawings or photographs. Do not hesitate to send specimens because they are "common." The term common as applied to these things is purely a relative term. Species which are common with you may be very uncommon in neighboring localities.

Circular No. 216 of the Forest Service of the United States Department of Agriculture, by W. H. Long, forest pathologist, calls attention to the effect of forest fires on standing hardwood

timber. Scars caused by comparatively insignificant fires furnish gateways through which insects and rot-producing fungi enter the tree. In spite of this fact, it is often claimed that small fires do not injure the forests and the claim is sometimes made that they are even beneficial. Studies made by the author of the article in Arkansas show that the continuous burning of the forests is causing annual losses of thousands of dollars. Most of this loss is caused by the indirect effect of the fire in paving the way for heart rot fungi and harmful insects. Most of these evil effects might be eliminated by coöperation of the people in preventing all fires, both large and small.

A short paper on "The production of a promycelium by the aecidiospores of *Caeoma nitens*" by Otto Kunkel in the July number of the Torrey Bulletin is of especial interest to students of the rusts. *Caeoma nitens,* the common orange leaf rust of the blackberry, has been considered the aecidial stage of *Puccinia Peckiana* Howe, both Tranzschel and Clinton having claimed to establish the connection through infection experiments. Kunkel, however, finds that these aecidiospores are functionally teleutospores. On germination they regularly give rise to a septate promycelium and sporidia. The normal promycelium consists of five cells four of which are uninucleated while the basal cell lacks a nucleus. Each nucleated cell produces a sporidium on a sterigma. The sporidia germinate immediately producing either secondary sporidia or germ tubes. Cytological studies of *Caeoma nitens* by Olive and Kurssanow have shown that a uninucleated mycelium precedes the formation of the aecidium and that the binucleated condition is brought about by cell fusions. The aecidiospores are binucleated. Kunkel's further observation on the germination of these aecidiospores suggests that nuclear fusion occurs in the aecidiospore and is followed by the reduction divisions in the promycelium. If this should prove to be the case the mycelium produced by infection with sporidia would be uninucleated and the life cycle of the fungus would be complete. *Caeoma nitens* would thus be a complete rust with a single spore form. This condition would be quite comparable to that found in several species of *Endophyllum* the only essential difference being that in species of

Endophyllum the aecidium is of the cup type. The determination of the complete life history of *Caeoma nitens* must await further infection experiments. It is of interest that this method of germination should have so long escaped detection in such a widely distributed and well known rust.—*F. D. Fromme.*

Phytopathology[1] for June contains a paper by Doctor W. C. Sturgis on *Herpotrichia* and *Neopeckia*. In this paper Doctor Sturgis calls attention to the similarity of *Neopeckia Coulteri* (Peck) Sacc. and *Herpotrichia nigra* Hartig. He mentions having seen only one reference[2] to *Herpotricha nigra* in American literature. In this connection it might not be out of place to call attention to a preliminary note on these two species in a report of the conference of the scientific staff and students of the New York Botanical Garden two years ago, as follows:[3]

"Mr. Fred J. Seaver showed specimens of two fungi (*Neopeckia Coulteri* and *Herpotrichia nigra?*) which occur as parasites on various coniferous trees at high altitudes in the Rocky Mountains. The two fungi are so much alike that they can be distinguished only by microscopic examination of the spores and for this reason the species have been hopelessly confused and most of the specimens in our collections are incorrectly named. So far as our observations have gone the one species (*Neopeckia Coulteri*) occurs only on species of pine, while the other (*Herpotrichia nigra*?) occurs on spruces and firs but never, so far as observed, in America on pine.

"*Herpotrichia nigra* was originally described in Europe and has been reported on both spruces and pines as well as on other coniferous trees. Examination of various European specimens of this species shows the spores to be much smaller than those examined in American specimens. Whether this difference in size which is very marked is due to the fact that the spores are immature is uncertain. Attempts to secure specimens of type material in order to determine the identity of the European species have so far been unsuccessful.

[1] Phytopathology 3: 152–158. *pl. 12, 13.* 1913.

[2] F. S. Earl in Green's Plantae Bakerianae 1: 27. 1900.

[3] Jour. New York Botanical Garden 12: 159. 1911.

"The fact that this European species occurs on both spruces and pines while the American specimens which are thought to be identical does not occur on pine and that this difference in habitat is accompanied by a difference in the size of the spores suggests the possibility that the American specimens may constitute a species distinct from the European.

"The pine inhabiting species of America (*Neopeckia Coulteri*) which is very different from the preceding species in spore characters is unknown to Europe. The results of these studies will appear more in detail in a paper to be published later."

Notes were in hand for the publication of a more extended paper on this subject with illustrations, but since this has been very well done by Doctor Sturgis it is no longer necessary. The paper covers the ground thoroughly and is accompanied by two plates showing both the gross and microscopic characters of the two species.

In the work on *Herpotrichia nigra* at the Garden some attempts were made to grow the species on culture media. The spores were found to germinate very readily and considerable mycelial growth was produced but no fruiting bodies were formed.—*F. J. Seaver.*

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MYCOLOGIA

VOL. V NOVEMBER, 1913 No. 6

ILLUSTRATIONS OF FUNGI—XVI

WILLIAM A. MURRILL

(WITH PLATES 102–108)

The accompanying figures represent some of the tough and woody fungi known as polypores. Most of the species of this group grow on dead wood in brackets of various sizes and shapes, the fruiting surface being composed of tubes or furrows. Sometimes the walls of these tubes split with age and the hymenium appears spiny, resembling the hydnums; sometimes the furrows change with age to appear like gills. When the fruit-body is perennial, the tubes are often arranged in layers. The family may be divided into four groups, the resupinates, the annual poroid species, the perennial poroid species, and the agaric-like species. The resupinate species are difficult for the beginner; some of the larger species of the other groups are comparatively easy. Polypores as a class are very destructive to trees and timber. On the other hand, one species possesses medicinal properties, some of the encrusted species supply tinder, and several of the more juicy ones are excellent for food if collected when young. The only species recognized as poisonous is the medicinal one, *Fomes Laricis,* and it is so tough and bitter that no one would think of eating it.

Coriolus versicolor (L.) Quél.

MANY-COLORED CORIOLUS

Plate 102

Pileus densely imbricate, very thin, sessile, dimidiate, conchate, 2–4 × 3–7 × 0.1–0.2 cm.; surface smooth, velvety, shining, marked

[MYCOLOGIA for September, 1913 (5: 257–286), was issued Oct. 4, 1913.]

with conspicuous, glabrous zones of various colors, mostly latericeous, bay or black; margin thin, sterile, entire; context thin, membranous, fibrous, white; tubes punctiform, less than 1 mm. long, white to isabelline within, mouths circular to angular, regular, even, 4–5 to a mm., edges thick and entire, becoming thin and dentate, white, glistening, at length opaque-isabelline or slightly umbrinous; spores allantoid, smooth, hyaline, 4–6 × 1–2 μ.

Abundant everywhere on dead wood, both in temperate and tropical regions, causing decay in tree trunks and often producing root-rot in trees when they are weakened by lack of food or other unfavorable conditions. The photograph is from a young black birch attacked by the fungus.

Coriolus prolificans (Fries) Murrill

LACERATE CORIOLUS

Plate 103

Pileus exceedingly variable, sessile or affixed by a short tubercle, dimidiate to flabelliform, broadly or narrowly attached, 2–5 × 2–6 × 0.1–0.3 cm.; surface finely villose-tomentose, smooth, white or slightly yellowish, marked with a few narrow, indistinct, latericeous or bay zones; margin thin, sterile, entire to lobed; context very thin, white, fibrous; tubes 1–3 mm. long, white to discolored within, mouths angular, somewhat irregular, 3–4 to a mm., usually becoming irpiciform at an early stage, edges acute, dentate, becoming lacerate, white to yellowish or umbrinous; spores smooth, hyaline.

Exceedingly abundant at times on dead deciduous trunks from Canada to Florida and west to Wisconsin and Mexico. I have seen oak trunks nearly a hundred feet long entirely covered with the fruit-bodies of this species. The walls of the tubes usually split at an early stage, causing beginners to mistake it for an *Irpex* or a *Hydnum*.

Irpiciporus mollis (Berk. & Curt.) Murrill

SOFT IRPICIPORUS

Plate 104

Pileus sessile, dimidiate, imbricate, decurrent, 3–4 × 4–8 × 1–3 cm.; surface white, finely pubescent, azonate, sulcate at times,

often aculeate behind with age; context white, coriaceous, 1–5 mm. thick; tubes soon splitting into teeth, which are 1–2 cm. long, compressed to subulate, slender, more or less pointed, dentate or incised, puberulent to glabrous, white to pale-flesh-colored, about 1 mm. apart at the base; spores globose, smooth, hyaline, 5–7 μ.

This species occurs rather sparingly on dead deciduous wood in temperate North America. It is interesting because of its close resemblance to the Hydnaceae. The specimens figured were collected on the Garden grounds in August, 1911, growing on the dead top of a red maple fifty feet above the ground.

Poronidulus conchifer (Schw.) Murrill

SHELL-BEARING POLYPORE

Plate 105. Upper Figure

Pileus thin, coriaceous, dimidiate to flabelliform, usually narrowly attached, conchate, springing from a sterile, cup-like structure, which usually appears on the mature sporophore near the base, 1.5–2 × 2–4 × 0.1–0.2 cm.; surface white to isabelline, with pale-latericeous zones, finely tomentose to glabrous, the sterile portion avellaneous, with narrow, black, concentric lines; margin thin, concolorous, undulate; context very thin, membranous, white, less than 1 mm. in thickness; tubes short, about 1 mm. long, thin-walled, white, mouths angular, irregular, 3 to a mm., edges thin, uneven, dentate; spores ellipsoid, smooth, hyaline.

Very common on fallen branches and dead limbs of elm throughout eastern North America as far west as Kansas. The genus is monotypic and is peculiar in having the fertile portion of the fruit-body develop from a sterile, cup-like growth, which is often found on the back of the mature pileus.

Scutiger griseus (Peck) Murrill

GRAY SCUTIGER

Plate 105. Lower Figure

Pileus circular, often irregular, convex, 7–12 cm. broad, 1 cm. or less thick; surface glabrous or minutely tomentose, cinereous, slightly darker toward the center; margin thin, concolorous, often

incurved on drying, irregular, undulate to lobed; context soft-fleshy, rosy-gray, about 5 mm. thick; tubes slightly decurrent, 1–2 mm. long, whitish-stuffed when young, white to pale-umbrinous within, mouths subangular, unequal, 2–4 to a mm., edges thin, entire to fimbriate, lacerate with age, white when young, becoming gray or umbrinous; spores subglobose, hyaline, echinulate, 5–6 × 4.5–5 μ; stipe central, thick, short, bulbous at the base, with surface and substance resembling that of the pileus, but darker in color, 4–5 cm. long, 1–1.5 cm. thick.

Found sparingly on the ground in open woods in New York, New Jersey, and Alabama. The specimens here figured were collected by Dr. F. M. Bauer near Amityville, Long Island, in September, 1911. The genus *Scutiger* approaches very near the Boletaceae, but the species are somewhat tougher and dry more easily. Of the dozen or more members of the genus in this country, all except two are very rare and local.

Grifola frondosa (Dicks.) S. F. Gray

FRONDOSE POLYPORE

Plate 106. Upper Figure

Pileus imbricate-multiplex, 15–40 cm. in diameter; pileoli very numerous, branching from a common trunk, imbricate or confluent, variable in size and shape, dimidiate to flabelliform, 1.5–6 cm. broad; surface smoky-gray, fibrillose, radiate-striate; margin thin, undulate or lobed, strongly inflexed when dry; context white, very thin, tough, fragile, having the odor of mice; tubes white, 2–3 mm. long, mouths circular and regular when young, 3 to a mm., often large and angular with age, edges white, thin, entire to lacerate; spores subglobose to ellipsoid, smooth, hyaline; stipe tubercular, white, connate-rimose.

This large, branched species grows commonly in Europe and North America at the base of oak trees or arises from their roots, on which it feeds. It also attacks the roots of chestnut trees, and in the Italian chestnut orchards it is often allowed to destroy its host because it is much esteemed in that region for food. It must be eaten when young or it will become too tough.

Daedalea quercina Pers.

OAK-LOVING BRACKET-FUNGUS

Plate 106. Lower Figure

Pileus corky, rigid, dimidiate, sessile, imbricate, applanate, convex below, triangular in section, 6–12 × 9–20 × 2–4 cm.; surface isabelline-avellaneous to cinereous or smoky-black with age, slightly sulcate, zonate at times, tuberculose to colliculose in the older portions; margin usually thin, pallid, glabrous; context isabelline, soft-corky, homogeneous, 5–7 mm. thick; tubes labyrinthiform, becoming nearly lamellate with age in some specimens, 1–2 cm. long, 1–2 mm. broad, chalk-white or discolored within, edges obtuse, entire, ochraceous to avellaneous.

This species is common on oak stumps and timbers throughout Europe and temperate North America, and is conspicuous by reason of its size and peculiar labyrinthiform fruiting surface, which becomes almost agaric-like with age.

Elfvingia megaloma (Lév.) Murrill

ARTISTS' BRACKET-FUNGUS

Plate 107

Plate 108. Upper Figure

Pileus hard, woody, dimidiate, applanate, 6–15 × 8–30 × 1–4 cm.; surface milk-white to gray or umbrinous, glabrous, concentrically sulcate, encrusted, fasciate with obscure lines, conidia-bearing, usually brownish during the growing season from the covering of conidia; margin obtuse, broadly sterile, white or slightly cremeous, entire to undulate; context corky, usually rather hard, zonate, fulvous to bay, 5–10 mm. thick, thinner with age; tubes very evenly stratified, separated by thin layers of context, 5–10 mm. long each season, avellaneous to umbrinous within, mouths circular, 5 to a mm., whitish-stuffed when young, edges obtuse, entire, white or slightly yellowish to umbrinous, quickly changing color when bruised; spores ovoid, smooth or very slightly roughened, pale-yellowish-brown, truncate at the base, 7–8 × 5–6 μ.

Originally described from specimens collected by Ménand in New York City. Found in great abundance throughout temperate North America on dead or diseased trunks or timber of most

deciduous trees, and on conifers in some sections. The tulip-tree here figured bore a number of new brackets each season for several years, while the older ones increased in size. Within the trunk of the tree, the delicate branching threads of the fungus permeated the wood in all directions seeking food and causing decay. In 1912, the tree was found to be so weakened that it had to be cut.

The brackets of this fungus are often collected by amateur artists and used for etching. The accompanying figure is from a specimen recently presented to the Garden by Mr. George E. Pollock. It grew near Lake Placid over one hundred years ago and was etched by a friend of the late James Ten Eyck to represent a view near the latter's camp in the Adirondacks.

Fomes ungulatus (Schaeff.) Sacc.

HOOF-SHAPED FOMES. PINE-LOVING FOMES

Plate 108. Lower Figure

Pileus corky to woody, ungulate, 8–15 × 12–40 × 6–10 cm.; surface glabrous, sulcate, reddish-brown to gray or black, often resinous; margin at first acute to tumid, pallid, becoming yellowish or reddish-chestnut; context woody, pallid, 0.5–1 cm. thick; tubes distinctly stratified, 3–5 mm. long each season, white to isabelline, mouths circular, 3–5 to a mm., edges obtuse, white to cream-colored; spores ovoid, smooth, hyaline, 6 μ.

A large species widely distributed in temperate regions on coniferous trees, such as pine and hemlock, and found more rarely on certain deciduous trees growing near its usual hosts.

NEW YORK BOTANICAL GARDEN.

View of upper surface

View of lower surface

CORIOLUS PROLIFICANS (Fries) Murrill

IRPICIPORUS MOLLIS (Berk. & Curt.) Murrill

PORONIDULUS CONCHIFER (Schw.) Murrill

SCUTIGER GRISEUS (Peck) Murrill

GRIFOLA FRONDOSA (Dicks.) S. F. Gray

DAEDALEA QUERCINA Pers.

Elfvingia megaloma (Lév.) Murrill

Elfvingia megaloma (Lév.) Murrill

Fomes ungulatus (Schaeff.) Sacc.

TYPE STUDIES IN THE HYDNACEAE—VI. THE GENERA CREOLOPHUS, ECHINODONTIUM, GLOIODON, AND HYDNODON[1]

Howard J. Banker

Creolophus P. Karsten, Medd. Soc. Faun. et Fl. Fenn. 5: —— (28). 1879

Climacodon P. Karsten, Rev. Myc. 3[1]: 20. 1881.

The genus *Creolophus* Karst. was established on *Hydnum corrugatum* Fr. as the type. No type specimen of this species was found at Upsala but several specimens in the herbarium collected by P. A. Karsten, E. Th. Fries, and Fr. Kjellman in Sweden and Finland were referred to this species. All of these agree perfectly with Fries's description and may be regarded as authentic representatives of the species.

They do not appear to be generically different from *H. septentrionale* Fr., having much the same form, color, and fleshy or subfleshy substance. The species has not yet been positively recognized as an American form.

Climacodon Karst. was established on *Hydnum septentrionale* Fr. and is, therefore, a metonym of *Creolophus.*

We have hitherto included the species of this genus in the genus *Steccherinum.* The peculiar fleshy or subfleshy character of the substance of these plants, so strikingly different from the dry and tough fibrous character of typical *Steccherrinum,* has convinced us that they should be maintained in a separate genus for which a name has already been provided by Prof. Karsten.

Creolophus septentrionalis (Fries)

Hydnum septentrionale Fries, Sys. Myc. 1: 414. 1821.

There is no type of this species preserved at Upsala, but forms of the plant often found on beech in Indiana conform perfectly

[1] Investigation prosecuted with the aid of a grant from the Esther Herrman Research Fund of the New York Academy of Science.

in every respect to the figure given by Fries, Icon. *pl. 9, 10.* A fine, large specimen was found at Upsala that had grown on *Tilia* in the Botanical Garden. It differs from what appears to be the typical form of the plant in that the whole mass is much more elongated vertically, probably from its having emerged from a crack, and the pilei are smaller, thinner, and more numerous. Specimens reported in this country as growing on maple differ in some respects from the typical form on beech.

Creolophus agaricoides (Swartz)

Hydnum agaricoides Swartz, Prodr. 149. 1788.
Hydnum discolor Fries, Sys. Myc. 1: 411. 1821.

Swartz's type of *H. agaricoides* could not be located in Europe nor could a specimen of *H. discolor* Fr. be found in Fries's herbarium at Upsala: the species did not appear to be known there. Strangest of all, nothing was found in Berkeley's herbarium at Kew that in any way answered to his elaborate discussion with figures of this species in the Annals and Magazine of Natural History 10: 380. *pl. 10. f. 9.*

In 1909, Murrill and Harris discovered in the remarkable Cockpit country of Jamaica a plant that appears to answer in every essential feature the descriptions of Swartz and of Berkeley. As this region is the type locality of Swartz's species and as the specimen, *Murrill and Harris 1095,* conforms so well to Swartz's species and to no other, there seems to be the best of reasons for regarding it as representing the Swartzian species. It is the only specimen of the species that I know of and is preserved in the herbarium of the New York Botanical Garden.

Creolophus pulcherrimus (Berk. & Curt.)

Hydnum pulcherrimum Berkeley and Curtis, Hooker's Jour. Bot. and Kew Garden Misc. 1: 235. 1849.
Hydnum friabile Fries, Nov. Symb. Myc. 106. 1855.

The type of *Hydnum pulcherrimum* B. & C. is preserved in the Berkeley herbarium at Kew and is marked "*Hydnum pulcherrimum* B. & C. No. 1648. Santee River." The specimen is in

good condition and shows clearly that the species is our common American form.

At Upsala a specimen was found marked "*Hydnum pulcherrimum* Berk. & Curt. *H. friabile* Fr. ad *Liquidambar* dejecit. Carol. austr. M. A. Curtis." The handwriting was that of Curtis. Is this specimen the type of *H. friabile* Fr.? There was no other specimen found at Upsala named *H. friabile*. This specimen was certainly a good example of *H. pulcherrimum* B. & C. As Fries himself expressed doubt as to the species being distinct we are justified in regarding them as the same species.

ECHINODONTIUM Ellis and Everhart, Bull. Torrey Bot. Club 27: 49. Feb. 1900

Hydnofomes Hennings, Engler's Bot. Jahrb. 28: 267. Mar. 1900.
Hydnophysa Clements, Genera of Fung. 108. 1909.

The genus *Echinodontium* Ell. & Everh. was established on *Fomes tinctorius* Ell. & Everh. Bull. Torrey Club 22: 362. 1895. This species was originally described from a specimen received from Alaska and known as "Swan 20851." The type specimen is now preserved in the herbarium of the New York Botanical Garden. It has the teeth broken off even with the pileus and hence was described as a *Fomes*. Later, on obtaining more perfect specimens and discovering the hydnaceous character of the plant, Ellis established the genus *Echinodontium* for the species.

Hydnofomes Henn. was established on *H. tsugicola* Henn. & Shir., Engler's Bot. Jahrb. 28: 268. Mar. 1900. The species and genus were described from specimens collected at Nikko in Japan by Prof. Shirai and now preserved in the herbarium at Berlin. These specimens are smaller than the type of *Echinodontium tinctorium* Ell. & Everh. and appear to have a somewhat pendant habit; otherwise they do not appear to differ from our American species. It seems possible that the specimens are not typical of the species. The difficulties of transportation might readily account for the sending of undersized and perhaps poorly developed specimens. Until further collections in Japan show conclusively that the species is distinct from the American form, it seems necessary to regard the Japanese plant as the same species

as the American. The habitat and distribution of the plants give confirmation to this view. *Hydnofomes* Henn. must then be regarded as a synonym of *Echinodontium* Ell. & Everh.

Hydnophysa Clements is an unwarranted and a careless attempt to improve upon the name *Hydnofomes* Henn. It may be claimed that the change is in the interests of literary taste in dispensing with a hybrid name. If such be the ground for the proposed change, it seems rather far-fetched and pedantic; for while such considerations doubtless should have weight and be heeded by an author in the coining of a new name, it is by no means a sufficient reason for disturbing an established system of nomenclature. The proposed change is further unwarranted since the name *Hydnophysa* does not have the same significance as *Hydnofomes* and the change does violence to the purpose of the author of the genus. It is evident that Hennings intended to express by his name a relationship between *Hydnum* and *Fomes,* and, under the circumstances, such relationship could not be better expressed by the name. Since *Hydnophysa* suggests no such connection, the change defeats Hennings's purpose. A biologist ought to be the last to object to hybridism when it throws any light on the problems of the relationship of living things. The mistake that Ellis made in referring the Swan specimen to *Fomes* confirms the appropriateness of Hennings's name.

The proposal of the name *Hydnophysa* was also made carelessly and without sufficient investigation of the problem involved; for, although on the same page the name *Echinodontium* was noted by Clements and especially mentioned as included in *Hydnum,* there was a complete failure to perceive that it was generically identical with *Hydnofomes.* From which it is evident that a work claiming not to be critically taxonomic is no place for proposing important changes in nomenclature.

GLOIODON P. A. Karsten, Medd. Soc. Faun. et Fl. Fenn. **5**: 28. 1879

Sclerodon P. A. Karsten, Finlands Basidsv. 360. 1889.
Leaia Banker, Mem. Torrey Club **12**: 175. 1906.

A study of the European types concerned with this genus confirms the conclusions of a former paper on the nomenclature of

the group.[2] There need only be added here a brief account of the types still available in European herbaria. In Persoon's herbarium at Leyden were found two specimens, one marked "*Hydnum parasiticum* Pers. Syn." and the other marked "*Hydnum strigosum* Swartz. ———— *parasiticum* Pers. Syn.," both apparently in Persoon's hand. The latter was much the better specimen and showed clearly the peculiar characters which distinguish this genus. In Berkeley's herbarium, at Kew, there was found an abundant supply of material under the label "*Hydnum stratosum* Berk. Ohio No. 279," showing that the plant is precisely as we have previously treated it.

A reëxamination of Schweinitz's specimen in his herbarium in the Philadelphia Academy of Science shows it to be a distinct form from the type of this genus. Schweinitz referred it to *Hydnum strigosum* Swartz, but the hymenium appears to be distinctly poroid and I am inclined to think it should be referred to *Inonotus hirsutus* (Scop.) Murr.

Hydnodon gen. nov.

Hymenophore pileate, expanded, irregular; surface plane, orange to red; substance fleshy, thin, drying hard and brittle; stipe deformed; teeth short, stout, deformed, tuberculoid, reddish; spores minute, whitish, clouded, echinulate.

Hydnodon thelephorum (Lév.)

Hydnum thelephorum Lévéille, Ann. Sci. Nat. III. 2: 204. 1844.
Thelephora padinaeformis Montagne, Syll. Crypt. 175. 1856.
Hydnum lateritium Massee, Kew Bull. 1907: 124. 1907.

In the herbarium at Paris is a specimen marked "*Hydnum thelephorum* Lév. Ann. Sc. Nat. 3 ser. tom. II. p. 204. Cayenne. Lév." It seems probable that this specimen is the type specimen of the species. It agrees perfectly with specimens in the New York Botanical Garden collected in Jamaica, *Murrill 691,* and in the Bahamas, *Brace 4833*. The species is very distinct and well marked, not at all likely to be confused with anything else. In fact, so peculiar are its characters that it has seemed necessary to

[2] Banker, Mycologia 2: 7. 1910.

treat it as the type of a new genus. The spore characters show a relationship to *Phellodon, Auriscalpium* and *Gloiodon,* but the substance and structure of the pileus show more of an affiliation with *Hydnum.*

Thelephora padinaeformis Mont. is represented in the herbarium of the Paris Museum by a specimen marked "*Thelephora padinaeformis* Mont. Crypt. Guy. No. 401. Guyane Francaise. Legonier No. 914 (1850)." It seems altogether probable that this is the type specimen. It is precisely the same form as Léveillé's specimen. There are with this several other specimens of the same species also collected in Guyane Francaise which are much larger and show the characters of the plant remarkably well. It it a unique species, *sui generis.*

I have not seen the type of *H. lateritium* Mass., but his description appears to indicate the above species in every particular. Massee's specimens were from the "Gold Coast," Africa, and give an interesting extension of the distribution of this species.

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THE GENUS PSEUDOPLECTANIA

F. J. Seaver

(With Plates 109 and 110)

The genus *Pseudoplectania* was founded by Fuckel and originally included the two species, *P. nigrella* and *P. fulgens*. The latter species was later removed from the genus by Saccardo and made the type of a new genus *Otidella*. Two additional species, *P. melania* and *P. stygia,* were, however, added to the genus at this time. One of these, *P. stygia,* is probably a synonym of the older species, *P. nigrella*. If we retain *P. fulgens* in the genus, it then contains three valid species all of which are known from North America. The following is a synopsis of our present knowledge of the genus in North America.

Pseudoplectania Fuckel, Symb. Myc. 324. 1869

Caloscypha Boud. Bull. Soc. Myc. Fr. 1: 103. 1885.
Otidella Sacc. Syll. Fung. 8: 99. 1889.
Melascypha Boud. Hist. Class. Discom. Eu. 56. 1907.

Plants gregarious or scattered, sessile or stipitate, large, fleshy, externally clothed with short, slender, flexuous and often coiled or twisted hairs, sometimes giving to the exterior of the cup a tomentose appearance; asci cylindric-clavate, 8-spored; spores perfectly globose, smooth, hyaline; paraphyses straight or curved.

Type species, *Peziza nigrella* Pers.

Key to the Species

Plants entirely black or brownish black.
- Plants long-stipitate, sparingly clothed with straight or slightly flexuous hairs. *P. vogesiaca.*
- Plants short-stipitate or sessile and densely clothed with coiled hairs. *P. nigrella.*

Plants orange or occasionally with a greenish tint about the outer margin. *P. fulgens.*

Pseudoplectania vogesiaca (Pers.)

?*Peziza fuscocana* Alb. & Schw. Conspect. Fung. 312. 1805.
Peziza vogesiaca Pers.; Moug. & Nest. Stirpes Crypt. 584. 1818.
Peziza melania Pers. Myc. Eu. 1: 239. 1822.
Peziza melaena Fries, Syst. Myc. 2: 60. 1822.
Peziza spongiosa Peck, Bot. Gaz. 5: 35. 1880.
Pseudoplectania melaena Sacc. Syll. Fung. 8: 165. 1889.
Pulparia spongiosa Sacc. Syll. Fung. 8: 612. 1889.
Melascypha melaena Boud. Hist. Class. Discom. Eu. 56. 1907.

Plants large, attaining a diameter of 2–3 cm., cup-shaped or occasionally nearly plane, margin more or less wavy, externally black and very sparingly clothed with short, brown, flexuous hairs, stipitate, hymenium dark olivaceous-brown; stem variable in length, often 2–3 cm. and about 3 mm. thick, rooting below by a dense mass of dark brown, coarse hairs, 5–7 μ in diameter, both stem and exterior of the cup often longitudinally wrinkled, giving rise to vein-like markings, the whole plant often resembling a gill fungus; asci cylindric with a very long stem-like base, entire ascus 200–275 $\times$ 16–18 μ; spores 1-seriate, globose with one large oil-drop, at first hyaline, becoming very pale brown, smooth; paraphyses slender, brown and coiled or hooked at their apices, about 3–4 μ in diameter.

On decaying wood among moss, especially *Sphagnum,* in coniferous woods.

TYPE LOCALITY: Europe.

DISTRIBUTION: Vermont to Minnesota; also in Europe.

ILLUSTRATIONS: Boud. Ic. Myc. *pl. 343;* Cooke, Mycogr. *pl. 49, f. 193;* Rabenh. Krypt. Fl. 1[3]: 1030, *f. 1.*

Cotype material of *Peziza spongiosa* Peck (*Pulparia spongiosa* Sacc.) has been examined and this agrees in every detail with cotype material of *Peziza vogesiaca* Pers. as shown in the accompanying plates. The only other American specimens of this species examined were collected by Macoun in British Columbia, June 4, 1889, and referred to *Peziza spongiosa* Peck. The species has been reported from Minnesota by Miss Daisy Hone[1] as *P. melaena* Fr. It has also been reported from Wisconsin by Dr. B. O. Dodge in a paper now in press.

[1] Minnesota Botanical Studies 4: 70. 1909.

Peziza fuscocana Alb. & Schw. is claimed to be the same, and, if so, the name has priority. No authentic material of this species has been seen.

PSEUDOPLECTANIA NIGRELLA (Pers.) Fuckel, Symb. Myc. 324. 1869

Peziza nigrella Pers. Syn. Fung. 648. 1801.
?*Peziza stygia* Berk. & Curt. Grevillea 3: 153. 1875.
Plectania nigrella Karst. Act. Soc. Fauna Fl. Fenn. 2: 119. 1885.
?*Pseudoplectania stygia* Sacc. Syll. Fung. 8: 166. 1889.
Otidella nigrella Schr. in Cohn Schles. Kryptfl. 3^2: 48. 1893.
Lachnea nigrella Gill. Discom. 78. (1874?)

Plants gregarious or occasionally closely crowded, sessile or substipitate, at first closed and subglobose, becoming expanded and cup-shaped or nearly plane, hymenium brownish-black, margin often wavy and slightly incurved, externally clothed with very fine hairs, 5 mm. to 1.5 cm. in diameter; hairs very long but usually closely coiled and twisted giving to the exterior of the cup a slightly tomentose appearance, of nearly uniform thickness throughout their entire length, sparingly septate and pale brown, 4–6 μ in diameter; asci cylindric or subcylindric with a long stem-like base, entire ascus often as long as 300–325 μ and about 15 μ in diameter at the thickest point; spores with a large oil-drop or often with several smaller ones, 12–14 μ in diameter; paraphyses enlarged at their apices and filled with brown coloring matter, about 4 μ thick.

On the ground in coniferous woods, among moss, especially *Sphagnum*.

TYPE LOCALITY: Europe.

DISTRIBUTION: New Jersey to Wisconsin, Alabama and Jamaica; also in Europe.

ILLUSTRATIONS: Boud. Ic. Myc. *pl. 344;* Cooke, Mycogr. *pl. 31, f. 120;* Gill. Discom. *pl. 65.*

Peziza stygia Berk. & Curt. differs only in its smaller size and longer stem. A fragment of the Carolina specimen has been examined and it seems doubtful if the species is distinct. Later collections may, however, prove it to be so.

PSEUDOPLECTANIA FULGENS (Pers.) Fuckel, Symb. Myc. 324. 1869

Peziza fulgens Pers. Myc. Eu. 1: 241. 1822.
Peziza cyanoderma deBary in Rabenh. Fungi Eur. 516. 1863.
Aleuria fulgens Gill. Champ. 41. 1879.
Otidella fulgens Sacc. Syll. Fung. 8: 99. 1889.
Barlaea fulgens Rehm in Rabenh. Krypt. Fl. 1^3: 930. 1896.
Calossypha fulgens Boud. Ic. Myc. 1908.

Plants cup-shaped, regular or irregular, often unequal sided, substipitate below and attached to the substratum by a dense mass of coarse mycelium which penetrates into the substratum and binds it together; cup 1–2 cm. broad and of about the same depth, hymenium orange, externally paler and usually with a greenish tinge especially about the margin, clothed with poorly developed golden-yellow hairs or hair-like structures; asci cylindric, gradually tapering below; spores 1-seriate, hyaline, smooth, 6–8 μ in diameter; paraphyses rather stout, filled with golden-yellow oil-drops.

On soil in coniferous woods.

TYPE LOCALITY: Europe.

DISTRIBUTION: New York to Wisconsin.

ILLUSTRATIONS: Boud. Ic. Myc. *pl. 319;* Cooke, Mycogr. *pl. 53, f. 209;* E. & P. Nat. Pfl. 1^1: 179, *f. 146, C, D.;* Gill. Champ. *pl. 38.*

NEW YORK BOTANICAL GARDEN.

EXPLANATION OF PLATES CIX AND CX

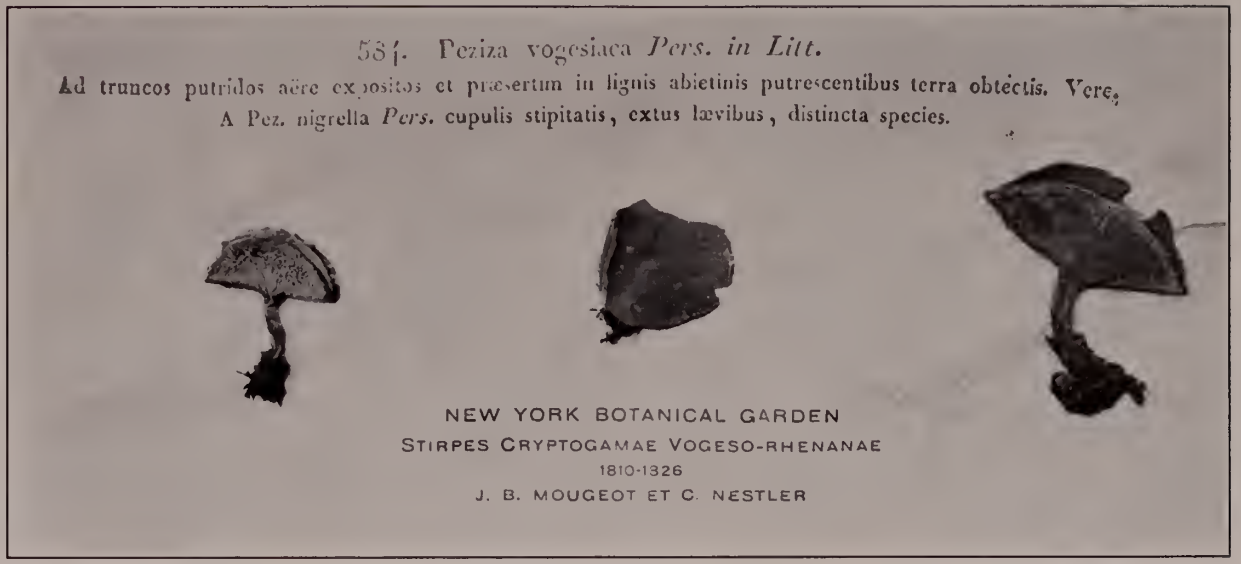
Plate 109 (upper figure). Cotype material of *Peziza spongiosa* Peck, which is identical with *Pseudoplectania vogesiaca* (Pers.) Seaver. Photographed in dried condition. Natural size.

Plate 109 (lower figure). *Pseudoplectania nigrella* (Pers.) Fuckel. Photographed from fresh specimens collected in a *Sphagnum* bog in New Jersey by Dr. B. O. Dodge. Natural size.

Plate 110. Cotype material of *Peziza vogesiaca* Pers., which was later described as the type variety of *Peziza melania* Pers. Photographed from herbarium specimen. Natural size.

PSEUDOPLECTANIA VOGESIACA (Pers.) Seaver

PSEUDOPLECTANIA NIGRELLA (Pers.) Fuckel


534. Peziza vogesiaca *Pers. in Litt.*
Ad truncos putridos aëre expositos et præsertim in lignis abietinis putrescentibus terra obtectis. Vere.
A Pez. nigrella *Pers.* cupulis stipitatis, extus lævibus, distincta species.
NEW YORK BOTANICAL GARDEN
STIRPES CRYPTOGAMAE VOGESO-RHENANAE
1810-1326
J. B. MOUGEOT ET C. NESTLER

PEZIZA VOGESIACA Pers. (cotype)

INTERNAL AECIA

Frederick A. Wolf

(With Plate iii)

Among the heteroecious rusts whose hosts grow in swampy situations is a form whose telial stage appears on species of *Scirpus* and whose aecial stage is developed upon one of the mints, *Lycopus virginicus* L. This rust, *Puccinia angustata* Peck,[1] is very abundant, during the month of May, in the vicinity of Auburn, Ala. The aecial sori may appear upon the stems, petioles and leaves, resulting in the hypertrophy of affected tissues. The enlargements upon the stems and petioles seem always to be more prominent than those upon the leaves. It was found upon sectioning the sori, which occurred upon both stems and petioles, that many of them not only possessed aecia which, upon dehiscence, liberate their spores to the exterior of the host, but also those which were entirely internal. In case the affected portions of the host are quite mature the pith cells will have disintegrated, causing the stem to be hollow, and the aecia then open into this cavity. If petioles or younger portions of the stem are affected, certain of the pith cells are broken down and the cluster cups open into the surrounding parenchyma tissue. As far as can be observed these internal cluster cups are similar in origin, structure, size and form to those which are erumpent at maturity. Masses of fungous tissue are present in certain places in which the aecia occur and the mycelium more or less densely ramifies throughout adjacent host tissues. These internal aecia may be so numerous that three or four will be present in a section ten micromillimeters in thickness.

The formation of aecia is usually subepidermal and when they are ready for anthesis they break through the epidermis. In the

[1] For this determination thanks are due Dr. J. C. Arthur, of Purdue University.

genus *Uredinopsis,* however, the aecia are indehiscent. It seems quite probable, moreover, that in genera which typically open to the exterior the occurrence of internal aecia is not at all uncommon and that this phenomenon has been previously observed by those who have studied rusts. Their occurrence in *Lycopus virginicus,* however, has not previously been recorded. Neither are there published accounts of their presence in other hosts so far as can be learned from the available literature relative to rusts. *Uromyces Caladii* (Schw.) Farl. is known[2] to form internal cluster cups in *Peltandra virginica* (L.) Kunth., and Reddick has observed them too in the fruits of the barberry. Not only it is probable that aecia quite commonly open within affected host tissues but also other stages of rusts as well. *Puccinia graminis* Pers. on rye bears uredinia, some of which liberate the uredospores into the interior of the hollow stems.[3]

A satisfactory explanation of the causes for the production of internal aecia cannot be given at this time further than to state that they must be the same as those which bring about the production of external aecia. In case the cluster cups of *P. angustata* originate near the center of the stem they must of necessity open within the stem. Those more deeply seated might push inward and open toward the center of the stem because there was less mechanical resistance than toward the outside. Rusts, whose spore forms are typically internal, depend upon the weathering away of overlying tissues for the liberation of the spores. The internal aecia of *P. angustata* are to be regarded, however, as the abnormal rather than as the typical condition and the surrounding host tissue cannot then serve this protective function.

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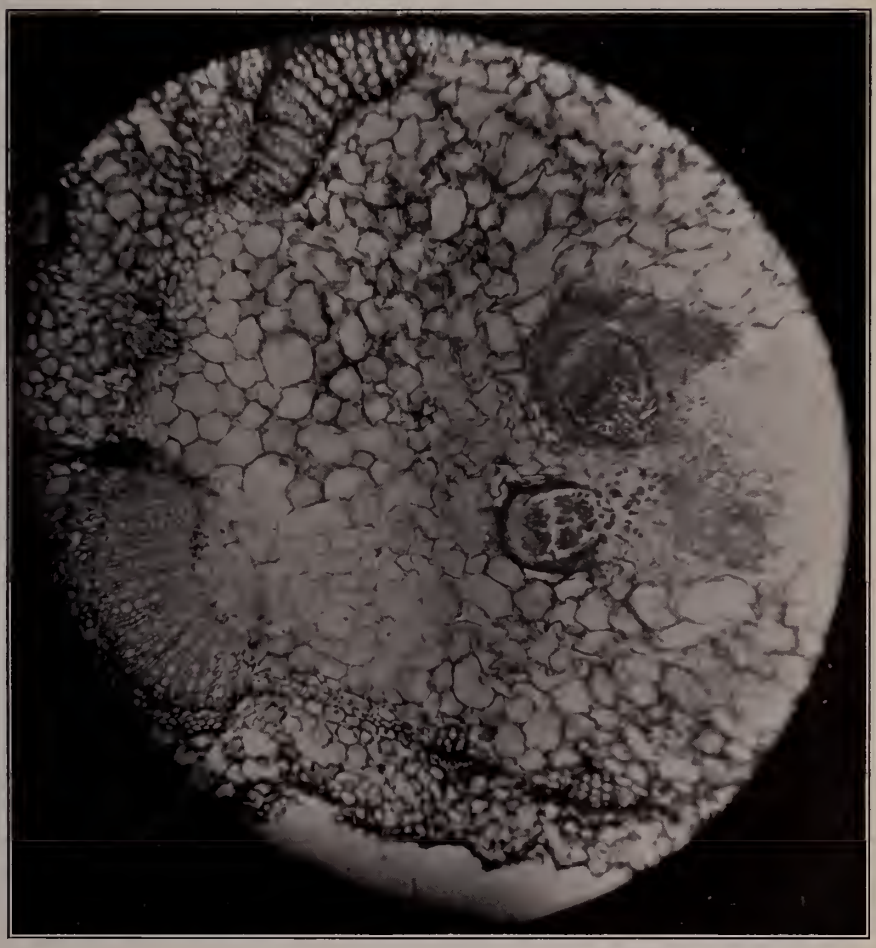
AUBURN, ALA.

[2] This observation was made by Prof. G. F. Atkinson, Cornell University, Dr. C. W. Edgerton, La. Exp. Station, and Dr. Donald Reddick, Cornell University, from material collected at Ithaca, N. Y. Thanks are due the above gentlemen for this information so kindly given in letters.

[3] A preparation showing internal uredinia was loaned through the courtesy of Dr. Donald Reddick, Cornell University.



Aecia of Puccinia angustata within the stem of Lycopus virginicus

THE LACTARIEAE OF THE PACIFIC COAST

GERTRUDE S. BURLINGHAM

At the request of Dr. W. A. Murrill, I have undertaken to list the species of *Lactaria* and *Russula* found on the Pacific Coast, as they are represented by specimens in the herbarium of the New York Botanical Garden.

Context lactiferous.	1. LACTARIA.
Context not lactiferous.	2. RUSSULA.

1. LACTARIA Pers. Tent. Disp. Meth. Fung. 63–65. 1797

1. LACTARIA DELICIOSA (L.) Fries, Epicr. 341. 1838

Agaricus deliciosus L. Sp. Pl. 1172. 1753.

Seattle, Washington, *Murrill 387;* Newport, Oregon, *Murrill 1130;* Mill City, Oregon, *Murrill 848;* Corvallis, Oregon, *Murrill 1010;* La Honda, California, *Murrill.*

The specimens from Seattle were collected during the last of October in a peat bog, in holes with skunk cabbage. In Oregon, they were found during the month of November, in fir and pine barrens near the coast and also in the foothills of the Cascade Mountains at an elevation of from 800 to 1,200 ft.

2. LACTARIA CHELIDONIUM Peck, Ann. Rep. N. Y. State Mus. 24: 74. 1872

Corvallis, Oregon, *Murrill 986,* in fir forest with scattered specimens of oak, birch, willow and maple, November 6–11.

3. LACTARIA SCROBICULATA (Scop.) Fries, Epicr. 334. 1838

Agaricus scrobiculatus Scop. Fl. Carn. 2: 450. 1772.

Fair Oaks, California, *Harper 48,* in February.

4. LACTARIA TORMINOSA (Schaeff.) Pers. Tent. Disp. Meth. Fung. 64. 1797

Agaricus torminosus Schaeff. Fung. Bav. Icon. 4: 7 (Index). 1774.
Lactarius villosus Clements, Bot. Surv. Neb. 4: 20. 1896.

La Honda, California, *Murrill & Abrams 1281.* These specimens were collected in November on the western slope of the Santa Cruz Mountains, in a dense redwood forest below 1,000 feet elevation.

5. LACTARIA INSULSA (Fries) Epicr. 336. 1838

Agaricus insulsus Fries, Myc. I: 68. 1821.

Santa Cruz Peninsula, California, near Searsville Lake, *McMurphy 26;* Mission Cañon, California, *Oleson 84.*

6. LACTARIA ZONARIA (Lamarck) Fries, Epicr. 336. 1838

Agaricus zonarius Lamarck, Fl. Fr. I (108). 1778.

Fair Oaks, California, *Harper 46,* in February.

7. LACTARIA TRIVIALIS (Fries) Fries, Epicr. 337. 1838

Agaricus trivialis Fries, Obs. Myc. 1: 61. 1815.
Lactarius deflexus Lindblad, Monogr. Lact. Suec. 8. 1855.

Mill City, Oregon, *Murrill 828;* Searsville Lake, Santa Cruz Peninsula, California, *McMurphy 25.* The specimens from Mill City may be faded specimens of *Lactaria circellata.*

8. LACTARIA CIRCELLATA (Fries) Fries, Epicr. 338. 1838

Agaricus circellatus Fries, Hym. Eur. 426. 1821.

Mill City, Oregon, *Murrill 798;* Glen Brook, Oregon, *Murrill 736.* These specimens were collected in coniferous woods containing some hardwoods, at an elevation of from 400 to 1,200 ft.

9. LACTARIA MUCIDA Burl. Mem. Torrey Club 14: 56. 1908

Seattle, Washington, *Murrill 539;* Mill City, Oregon, *Murrill 867.*

10. LACTARIA THEIOGALA (Bull.) Fries, Epicr. 342. 1838

Agaricus theiogalus, Bull. Herb. Fr. *pl. 567, f. 2,* 1793; Hist. 1: 495. 1809.
Lactarius brevipes Longyear, Rep. Mich. Acad. Sci. 3: 59. 1901.
Lactarius brevix Peck, Bull. N. Y. State Mus. 94: 33. 1905.

Lactarius xanthogalactus Peck, Bull. Torrey Club 34: 346. 1907.

Salem, Oregon, *M. E. Peck;* California, *Patterson.*

11. LACTARIA CAMPHORATA (Bull.) Fries, Epicr. 346. 1838

Agaricus camphoratus, Bull. Herb. Fries, *pl. 567, f. 1;* Hist. Champ. 493. 1809.

Santa Cruz Peninsula, California, *Miss Patterson 63;* Pasadena, California, *McClatchie.*

12. LACTARIA SUBDULCIS (Pers.) Fries, Epicr. 345. 1838

Agaricus lactifluus dulcis, Bull. Herb. Fr. *pl. 224, A, B.* 1784.

Agaricus subdulcis Pers. Syn. Meth. Fung. 433, 434. 1801.

Lactarius subserifluus Longyear, Rep. Mich. Acad. Sci. 1901: 57. 1902.

Corvallis, Oregon, *Murrill 1016;* Marin Co., California, *Eastwood;* in November and December.

13. LACTARIA MITISSIMA Fries, Epicr. 345. 1838

Agaricus mitissimus Fries, Syst. Myc. I: 69. 1821.

Seattle, Washington, *Murrill 430;* Mill City, Oregon, *Murrill 805.*

14. LACTARIA GRISEA Peck, Ann. Rep. N. Y. State Mus. 23: 119. 1873

Seattle, Washington, *Murrill 607.*

15. LACTARIA PIPERATA (L.) Pers. Tent. Disp. Meth. Fung. 64. 1797

Agaricus piperatus L. Sp. Pl. 1173. 1753.

Agaricus Listeri Withering, Nat. Arr. Brit. Pl. 4: 156. 1801 (Ed. 4).

Mission Cañon, Santa Barbara, California, *Oleson 123.*

16. LACTARIA VELLEREA (Fries) Fries, Epicr. 340. 1838

Agaricus vellereus Fries, Syst. Myc. I: 76. 1821.

Mission Cañon, Santa Barbara, California, *Oleson 123.*

The collection numbered *123* contains both specimens of *Lactaria piperata* and *Lactaria vellerea.*

2. RUSSULA (Pers.) Fries, Epicr. Myc. 349. 1838

1. RUSSULA DELICA Fries, Epicr. Myc. 350. 1838

Hypophyllum album, Paulet & Lév. Ic. Champ. 33. 1855.
Russula deliciosa Schröt. in Cohn, Krypt. Fl. Schles. 549. 1889.
Russula brevipes Peck, Ann. Rep. N. Y. State Mus. 54: 178. 1901.

Seattle, Washington, *Murrill 372, 378;* Corvallis, Oregon, *Murrill 994;* Preston's Ravine, near Palo Alto, California, *Murrill & Abrams 1204;* La Honda, California, *Murrill & Abrams 1279;* Santa Barbara, California, *Oleson 111.*

There has been more or less uncertainty regarding the identity of *Russula delica* Fries, arising from the fact that in his earlier descriptions he refers to the pileus as "nitidus," shining; but in a later work[1] he does not mention this characteristic. The gills do not always impress one as distant, but it is noticeable that in the dried specimens the gills are really set far apart. Fries also did not mention the occurrence of a greenish tinge on the gills, but Kauffman[2] notes that the specimens which he has seen growing around Stockholm, and which Romell refers to *Russula delica,* often have this characteristic. The greenish tint on the edges of the gills in the American plants is not generally noticeable until the mushroom is fully mature, and gills which show no sign of the color when gathered often become greenish-gray during the process of drying; the color, however, vanishes before the plant is dry. Fries says that *Russula delica* is similar to *Lactaria vellerea* and often confused with it, which would seem to indicate that *Russula delica* sometimes might give the impression of being tomentose. Our specimens do occasionally appear obscurely fibrillose in places as though the surface fibers had pulled apart from each other. *Lactarius exsuccus* Smith probably should be referred to *Russula delica.*

The Seattle number, *372,* is noted as having greenish gills.

2. RUSSULA NIGRICANS (Bull.) Fries, Syst. Myc. I: 60. 1821

Agaricus nigricans, Bull. Herb. Fr. *pl. 212.* 1784.
Russula nigrescens Krombh. pt. 9. 27. 1831.

[1] Monogr. Hymen. Suec. 2: 185. 1863.
[2] Rep. Mich. Acad. Sci. 11: 65. 1909.

Corvallis, Oregon, *Murrill 1012;* Newport, Oregon, *Murrill 1098.* These specimens were collected in mixed forests of fir, oak, willow and maple, in November, 1911. Number *1012* reached 15 cm. in diameter.

3. RUSSULA DRIMEJA Cooke, Grevillea 10: 46. 1881

Seattle, Washington, *Murrill 654,* collected late in October.

4. RUSSULA GRANULATA Peck, Ann. Rep. N. Y. State Mus. 53: 843. 1900

Presidio, California, *Harper 68,* March 12, 1911.

5. RUSSULA EMETICA Fries, Epicr. Myc. 357. 1838

Newport, Oregon, *Murrill 1063;* California, *Harper.*

6. RUSSULA VETERNOSA Fries, Epicr. Myc. 354. 1838

Mission Cañon, Santa Barbara, California, *Oleson 87,* under oaks, April 15, 1913.

7. RUSSULA TURCI Bres. Fungi Trid. 22. 1881

Seattle, Washington, *Murrill 640;* Corvallis, Oregon, *Murrill 1007.* These were found in fir forests mixed with maple and birch. In *640,* the pileus reached the diameter of 9 cm.

8. RUSSULA CHAMELEONTINA Fries, Epicr. Myc. 363. 1838

Seattle, Washington, *Murrill 686;* La Honda, California, *Murrill & Abrams 1271.*

The La Honda specimens were found growing in a dense redwood forest, November 25, 1911, below an elevation of 1,000 ft.

9. RUSSULA ABIETINA Peck, Ann. Rep. N. Y. State Mus. 54: 160. 1901

Seattle, Washington, *Murrill 275,* in deep coniferous woods.

10. RUSSULA OBSCURA Rom. Öfvers. k. Vetensk.-Akad. Förhandl. 179. 1891

Seattle, Washington, *Murrill 602,* under fir, hemlock, maple, late in October.

11. RUSSULA ALUTACEA Fries, Epicr. Myc. 362. 1838

Agaricus alutaceus Fries, Syst. Myc. I: 55. 1821.

Tacoma, Washington, *Murrill 721.*

These specimens which I am referring to *Russula alutacea* differ from the description in two respects; the pruinose gills and the unfading pileus. Upon comparison with better foreign material than I have yet been able to obtain, it may be possible to clear away any doubt. They were abundant along the border of a lake in deciduous and evergreen forests. The pileus is broad, depressed, slimy, with separable pellicle, very dark purple-black, up to 15 or more cm. broad, with an even margin; the gills are cream-colored, avellaneous when dry and dusted with spores, sinuate; stipe equal, rose-colored, 10 cm. long, 2.5–3 cm. thick; spores yellow, broadly ellipsoid, echinate; taste mild, odor none.

12. RUSSULA FLAVICEPS Peck, Ann. Rep. N. Y. State Mus. 53: 843. 1900

Near Searsville Lake, California, *McMurphy 20,* December 28, 1902.

14. **Russula crenulata** sp. nov.

Pileus broadly convex, then plane to depressed, up to 9 cm. broad; surface milk-white or slightly yellow, viscid when moist, pellicle easily separable, glabrous; margin thin, slightly tuberculate-striate with age; context fragile, white, taste very acrid; lamellae white, equal, adnate, plane, edges appearing under the lens finely notched or crenate, not forking, rounded at the outer end, narrowed at the inner, pruinose, close; stipe white, spongy, nearly equal or enlarged below, glabrous, 10 cm. long, 2 cm. thick; spores white, mostly globose, echinulate, 10 μ in diameter.

Type collected at Glen Brook, Oregon, in a dense fir forest with a few oaks, November, 1911, *W. A. Murrill 762.* This species differs from *Russula albidula* Peck in its larger size; crenulate gills, which are broader and adnate rather than decurrent; in the absence of forking gills; and in the slightly tuberculate-striate margin.

15. **Russula Murrillii** sp. nov.

Pileus convex, becoming plane then depressed, up to 5 cm. broad; surface violaceous or darker in the center or entirely

darker, pruinose, becoming floccose-pruinose, evidently viscid when wet but soon dry; margin even; context white, thin, taste not noted; lamellae ochroleucous when fresh, becoming deeper yellow, equal, venose connected, rarely forking next to the stipe, rounded at the outer end, narrowly adnate at the inner end, subdistant, rather broad; stipe chalk-white, unchanging in drying, nearly equal, firm, stuffed, then tending to become hollow, glabrous; spores pale-yellow, echinulate, some globose, but many ellipsoid, $10 \times 7\ \mu$.

Type collected in fir forests with scattered specimens of oak, birch, willow, and maple, November 6, 1911, Corvallis, Oregon, *W. A. Murrill 965*. This species resembles *Russula azurea* Bres., but differs in the color of the pileus and the lamellae, which in *R. azurea* are white and remain white. It is a beautiful plant, characterized by its violet cap and pure-white stem. It is to be hoped that other collections of this species will soon be made and the taste recorded.

15. **Russula bicolor** sp. nov.

Pileus broadly convex, soon nearly plane, up to 8 cm. broad; surface coppery-red intermixed with pale-yellow or ocher, viscid when moist, pellicle separable on the margin, glabrous; margin even, becoming striate when mature; context white, subfragile, acrid to the taste; lamellae white, drying yellowish, equal, broad at the outer end, narrowed at the inner end but not free, interveined, subclose; stipe white, spongy, becoming hollow, 4.5 cm. long, 1.5 cm. thick or smaller; spores white, subglobose, echinulate.

Type collected under yellow birch in mixed woods, Newfane, Vermont, *Burlingham 39–1911*. Number *807, Murrill,* Oregon, seems to be the same.

16. RUSSULA PECTINATA (Bull.) Fries, Epicr. Myc. 358. 1838

Seattle, Washington, *Murrill 407*.

NEW YORK BOTANICAL GARDEN.

NEWS AND NOTES

The autumn meeting of the New York State Forestry Association was held at the Garden on October 17.

Dr. Ralph Jones has resigned from the Bureau of Plant Industry at Washington to become professor of botany at Emory College, Oxford, Georgia.

Professor W. C. Sturgis, formerly of the Connecticut Agricultural Experiment Station and now connected with Colorado College, visited the Garden October 15.

Mr. S. R. Winston, formerly assistant in plant pathology at the North Carolina Agricultural Experiment Station, has been appointed plant pathologist at the Hood River Branch Experiment Station in Oregon.

Mr. H. L. Rees has moved to the Western Washington Experiment Station, and Mr. G. H. Godfrey now fills the position vacated by Mr. Rees at the Oregon Agricultural Experiment Station.

Professor Adolf Engler, director of the Berlin Botanic Garden and senior author of the well-known systematic work on natural plant families, spent October 17 at the Garden, and met most of the local botanists socially in the evening at a dinner given in his honor.

Dr. E. D. Clark, known to the readers of MYCOLOGIA for his chemical investigations of the poisonous properties of certain fungi, has resigned his position in the Cornell Medical College to accept one in the Bureau of Chemistry at Washington.

Sterile Form of Pholiota candicans (Bull.) Schroet.

Mr. L. O. Overholts, who holds a Lackland research fellowship at the Missouri Botanical Garden, spent six weeks during the past summer at Tolland, Colorado, collecting flowering plants and fungi. He expects to publish some account of his fungous collections in a few months.

A paper on the species of *Synchytrium* in the vicinity of Stanford University, by James McMurphy, appeared in the Dudley Memorial Volume of the Leland Stanford Junior University Publications for March, 1913. The following species are reported: *S. papillatum* Farlow, *S. innominatum* Farlow, *S. andinum* Lagh., and *S. Amsinckiae;* the last, occurring on *Amsinckia intermedia,* being described as new. *Urophlyctis pluriannulatus* Farlow is also reported.

A comparative study of the development of the fruit body in *Phallogaster, Hysterangium,* and *Gautieria* has been made by Mr. H. M. Fitzpatrick at Cornell University, and the results published in a recent number of *Annales Mycologici* with copious illustrations. The author discusses rather fully some of the latest opinions regarding the relationship and origin of the different large groups of gastromycetes and suggests that a careful developmental study be made also of *Dendrogaster, Protoglossum, Gymnoglossum,* and *Clathrogaster,* with a view to solving problems connected with the evolution of the gastromycetes. He outlines the following series as illustrating the origin of the Clathraceae: *Gautieria — Chamonixia — Hysterangium — Protubera — Phallogaster — Clathraceae* (*Clathrella Clathrus*).

Miss Adeline Ames has recently published in the *Annales Mycologici* an excellent paper on structure as related to genera in the Polyporaceae, illustrated with 4 plates, containing 76 figures. The genera recognized are *Polyporus, Bjerkandera, Ischnoderma, Cryptoporus, Piptoporus, Favolus, Porodisculus, Phaeolus, Coriolus, Trametes, Daedalea, Polystictus, Phellinus, Fomes,* and *Ganoderma.* Four of these are monotypic, and four others con-

tain very few species; so that most of the polypores are distributed among seven genera, according to this classification. The genus *Polyporus* is divided into four sections on the presence or absence of a stipe and the simple or duplex character of the trama. This will appeal to those who are accustomed to the old cumbersome arrangement adopted by Saccardo and who look upon a generic name as something sacred. Others, perhaps, who consider a genus simply as a group of species more closely related to each other than to any other group, will prefer a simpler and more modern system.

STERILITY IN PHOLIOTA CANDICANS (BULL.) SCHROET.

A very interesting sterile form of this species, ordinarily known as *Pholiota praecox,* appeared in 1910, 1911, and 1912 under a large white oak on the grounds of the New York Botanical Garden. The lamellae were exceedingly thin and remained white, as shown in the accompanying illustration. The sterility was absolute and without apparent cause. A few fertile sporophores were found scattered among the sterile ones as though arising from the same mycelium. It occurred to the writer that this subject might be a good one for investigation by some graduate student. In this particular case, also, there might be a chance to cultivate an early "seedless" variety of mushroom for the market which would not be discolored by spores nor expend its energies on producing spores instead of edible substance.

Other cases of sterility in gill-fungi have been noted rarely by mycologists. Dr. Peck mentions a case of sterility in *Psilocybe uda;* and Dr. B. O. Dodge tells me that he once collected two baskets full of a sterile species of *Clitopilus.* The abortions of *Clitopilus abortivus* and *Armillaria mellea* before the gills are formed are generally well-known, but the reason for them may not be so clear. Another class of abortions not accompanied by sterility is represented by *Abortiporus distortus* and various species of *Ptychogaster.*

W. A. MURRILL.

The Genus Synchytrium[1]

This monograph represents several years of careful and painstaking work on the genus, which was founded by De Bary and Woronin in 1863 for two species, *S. Taraxaci* and *S. Succsiae.* The morphology, cytology, biology, and relation of the fungus to its host are treated in detail both by a review of the extensive literature and from original studies. The taxonomic portion of the paper shows marked conservatism, both by the retention of species such as *S. pluriannulatum,* which recently have been transferred to other genera, and by following the older systems of classification. The genus is divided into two subgenera, *Eusynchytrium,* to which 9 species are assigned, and *Haplochytrium* (the genus *Pycnochytrium* Schröter) with 17 species. Of the remaining species, 25 are not distributed and 12 are classed as doubtful. No further comment is necessary concerning the need of additional life history studies on species of the genus. Of the 63 species included, 3 are new. While *S. aureum* possesses an array of 130 hosts and numerous named forms, no member of the genus can be called cosmopolitan, at least from the data given. The geographical distribution is as follows: North America 21 species, South America 7, Europe 35, Asia 5, Africa 3, Australia 2, and New Zealand 1. Of the North American species, 12 are endemic, 8 are also found in Europe, 2 in Africa, and 1 in Australia. The excellent plates, the indexes, and the careful treatment of the subject matter will make this work of great value to all students of the lower fungi.

Guy West Wilson.

A Bad Year For Fleshy Fungi

The past season has been peculiarly unfavorable for the growth of fleshy fungi in the region about New York. The heavy rains late in September and October brought out certain species in great numbers, but they came too late for most of the summer and early autumn forms.

The shaggy-mane, *Coprinus comatus,* occurred again this year

[1] Die Synchytrien. Studien zu einer Monographie der Gattung. Von Dr. Gertrud Tobler geb. Wolff. Archiv fü Protistenkunde 28: 141–238, *pl. 10–13,* 1913. Also issued as a repaged separate, 8°. pp. 98, *pl. 4.* 1913.

as it did last year in the greatest abundance on a new street east of the New York Botanical Garden which was heavily surfaced with topsoil and allowed to grow up in weeds. Under similar conditions, Mr. George E. Pollock found great quantities of this species at Holmesdale, Massachusetts, growing in tufts almost as close as those of *Coprinus atramentarius.*

The giant puffball, *Calvatia maxima,* also appears to have been unusually abundant this year. One specimen was found on the grounds of the Garden, and a very attractive group developed in Mr. Boeder's yard in Williamsbridge, just north of the Garden reservation. Photographs of this group made by Mrs. Boeder have been added to the mycological collection. Another recent addition is a photograph of a giant puffball from Sendai, Japan, taken by Professor A. Yasuda.

The common field puffball, *Calvatia cyathiformis,* about the size of one's fist and very safe for the amateur mycophagist, was abundant early in October.

Pleurotus ulmarius has been more abundant than usual, growing from knotholes and wounds in elm trees. The white elm has suffered greatly in this vicinity from the attacks of the leaf-beetle, borer, and other causes. In its weakened condition, it cannot easily withstand the invasion of fungi.

The fly agaric, *Amanita muscaria,* appeared in greater abundance than ever before, under the white pines on the grounds of the Garden. Yellow forms prevailed, while many specimens were almost white, and very few showed a decided orange tint. Many years ago, the Italian immigrants are said to have eaten this species by mistake for *Amanita Caesarea,* but there is no evidence that they do this now. The large number of deaths from mushroom eating in New York in recent years has undoubtedly been due to mistaking the white form of *Amanita phalloides* for the ordinary field mushroom or some other edible fungus. *Armillaria mellea,* when growing singly in soil, might at times be confused with a pale form of *Amanita muscaria* by ignorant collectors, who would hardly notice the cottony ring of the former and the patches instead of scales on the surface of the latter.

W. A. MURRILL.

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